NEW HARMSWORTH SELF-EDUCATOR

EDITED BY ARTHUR MEE

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A KEY TO THE HARMSWORTH SELF-EDUCATOR

From this table of the 25 groups of the Self-Educator the student may find the place of any subject treated in the work. The main groups appear in regular numerical order in each part of the Educator, each group continuing until complete. The sub-divisions of the groups appear as nearly as possible in the order of this page.

Group 1. Success

The Secrets of a Successful Life. Personality. Applied Education. Ideas. The Qualities that Win in the World.

Group 2. Geography and Travel

Geography. Physical, Political, and Commercial.
Travel. Educational Travel. How to See the World.

Group 3. Arts and Crafts

Art. Ideals and History of Art. The Old Masters.
Drawing. Freehand. Object. Brush. Memory. Light & Shade.
Painting. Theory and Training.
Design. Design in Crafts and Trades. Book-decoration. Illumination. Design for textiles, wallpapers, metal work.
Sculpture. Modelling. Chiselling. Casting.
Architecture. Theory. Styles. Training.
Carving. Wood. Bone. Ivory. Tortoiseshell.
Art Metal Work. A Practical Course.
Photography. A Course of Simple Lessons with a Camera.

Group 4. Physiology and Health

Physiology. Structure and Working of the Human Body.
Health. The Laws of Health and Personal Hygiene.

Group 5. Agriculture and Gardening

Farming. A Practical Course in the Cultivation of the Earth. Live-stock. Dairying. Poultry. Beekeeping.
Forestry. The Theory and Practice of Managing Trees.
Gardening. Gardens for Pleasure and Profit.

Group 6. Chemistry

Chemistry. Complete Course in Theory and Practice.
Applied Chemistry. The Applications of Chemistry in Industry. Chemical Analysis. Acids and Alkalies. Oils and Fats. Waxes. Candles. Soap. Glycerine. Volatile Oils and Perfumes. Paints and Polishes. Glues. Starch. Inks. Coal Tar Products. Wood Distillation. Celluloid. Matches. Artificial Manures. Electro chemistry. Water-Softening. Waste Products. Artificial Silk.

Group 7. History

The Story of All Ages and Peoples for Over Ten Thousand Years—From Egypt and Babylon to Europe in 1914.

Group 8. Civil Engineering and Transit

Civil Engineering. Surveying. Varieties of Construction. Reinforced Concrete. Roads. Bridges. Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses.
Vehicles. Construction and Use. Cycles. Cabs, Buses, Trams.
Motors. Design and Management of a Motor Car.
Aviation. Science and Management of Flying Machines.
Railways. The Management and Control of Railways.
Shipbuilding. Shipping. Design and Construction.

Group 9. Literature and Journalism

Literature. A Survey of English Literature and Foreign Classics. The World's Great Books and their Writers.
Journalism. How to Become a Journalist. A Guide to Newspaper Life. How to Write. The Journalist's System.
Printing. Composing by Hand and Machine—Linotype and Monotype. Stereotyping and Printing.
Type. Type Cutting and Founding.
Engraving and Etching. Blockmaking and Process Work.
Lithography. Printing from the Stone.
Bookbinding and Publishing. Binding and Issuing Books.

Group 10. Civil Service and Professions

Civil Service. The Three Branches of the Public Services of the British Empire—Municipal, National, Imperial.
Banking. The Whole Practice of Banking.
Law How to Become a Solicitor or Barrister.
Medicine. Training of a Doctor. Veterinary Surgeons. Dentists. Chemists and Druggists. Nurses.
Insurance. Health. Unemployment. Life. Fire. Accident.
Auctioneering and Valuing. Practical Training.
Estate Agency. Management of a Great Estate.
Church. How to Enter the Ministry of all Denominations.
Scholastic. Teachers. Professors. Governesses. Tutors.
Secretaries. Institution Officials. Political Agents. Lecturers.
Libraries. Management of Libraries. Cataloguing.
Army, Navy, Merchant Service. How to Enter Them.

Group 11. Life and Mind

Biology. The Rise of Life. Evolution. Heredity.
Psychology. The Mind of Man.
Sociology. Social Conditions. Welfare of Communities.
Eugenics. Human Betterment and the Future of the Race.

Group 12. Business

Business. The Management of a Successful Business System. Simple Political Economy.
Shopkeeping. All Kinds of Shops and Small Trades.
Advertising. The Value of Advertising. How to Advertise. How to Write Advertisements. How to Get Them.

Group 13. Physics and Power

Physics. The Science of Matter and Motion.
Power. Sources and Uses of Power. Air. Water. Wind. Sun. Steam. Oil. Gas. For Electricity, see Group 16.
Prime Movers. Structure and Management of all Engines.

Group 14. Building Trades

Building. The Building Trades and Building Materials: their Manufacture and Use. Building a House. Excavating. Drainage. Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smith's Work. Painting. Papering and Glazing. Heating. Lighting. Ventilation. Quantity Surveying.
Wood-working Machinery. The Machines Used in Working Wood: Sawing, Turning, Planing, Moulding.
Cabinet-making and **Upholstering.**

Group 15. Natural History

Botany. Flowers. Plants. Seeds. Trees. Ferns. Mosses. Fungi.
Zoology. Mammals. Birds. Fishes. Reptiles. Insects. Lower Forms of Life.
Bacteriology. The Story of Microbes. Bacteriology in Relation to Health and Industry.

Group 16. Electricity

Electricity. Its Development and Countless Applications. Electrical Engineering.
Telegraphs and Telephones. The Instruments and How to Operate Them.
Wireless Transmission. The Main Systems and their Methods of Working.

Group 17. Music

Old Notation and Tonic Solfa. Tuition in All Instruments. Orchestration.
Elocution and Singing. The Voice and its Treatment.
Musical Instruments. Their Design and Manufacture.

Group 18. Manufactures

Textiles. The Textile Trades from Beginning to End. Cotton. Wool. Silk. Hemp. Flax. Jute. Carpets.
Leather. The Leather Industry. Tanning. Boots and Shoes. Saddlery. Belting. Gloves. Sundry Leather Goods.
Glass. Manufacture of All Kinds of Glass. Stained Glass.
Earthenware. The Craft and Industry of Pottery.
Paper. Papermaking of All Kinds.
Rubber. The Source and Preparation of Rubber, and Manufacture of Rubber Goods.
Tobacco. Cultivation and Manufacture. Tobacco Pipes.
Food Supply. Milling. Breadmaking. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation.
Beverages. Tea. Coffee. Chocolate. Cocoa. Brewing. Wines and Ciders. Mineral Waters.
Basketmaking. Cork. Wattle. Cane. Barks. Brushes.

Group 19. Astronomy. Geology. Archæology

Astronomy. The Universe as We Know It. Millions of Worlds. A Survey of the Solar System.
Geology. The Structure of the Earth. Petrology. Crystallography. Palæontology.
Archæology. Buried History. The New Story of the Old World as Revealed by the Excavator.

Group 20. Mechanical Engineering

Engineering. Applied Mechanics. Workshop Practice. Machine Tools. Machines and Appliances. Cranes.
Drawing for Coppersmiths, Tinmen, and Boilermakers.

Group 21. Languages

Latin. English. French. German. Spanish.

Group 22. Dress and Housekeeping

Dress. Principles of Dressmaking. Underclothing. Tailoring. Millinery. Hatters. Furs and Feathers.
Housekeeping. Domestic Management. Servants and their Duties. Cookery. Laundry.

Group 23. Metals and Minerals

Metals. Metallurgy. Properties and Characteristics of Metals. Iron and Steel. Copper. Tin. Zinc. Precious Metals.
Metal Manufactures. Arms and Ammunition. Cutlery. Clocks and Watches. Jewellery. Scientific Instruments.
Minerals. Mineralogy. Properties and Characteristics of Minerals.
Mining. Coal. Gold. Diamonds. Tin.
Quarrying. The Appliances and Processes of Extracting and Preparing Stone.
Gas. The Process of Manufacture.
Petroleum. Extraction and Refining Processes.

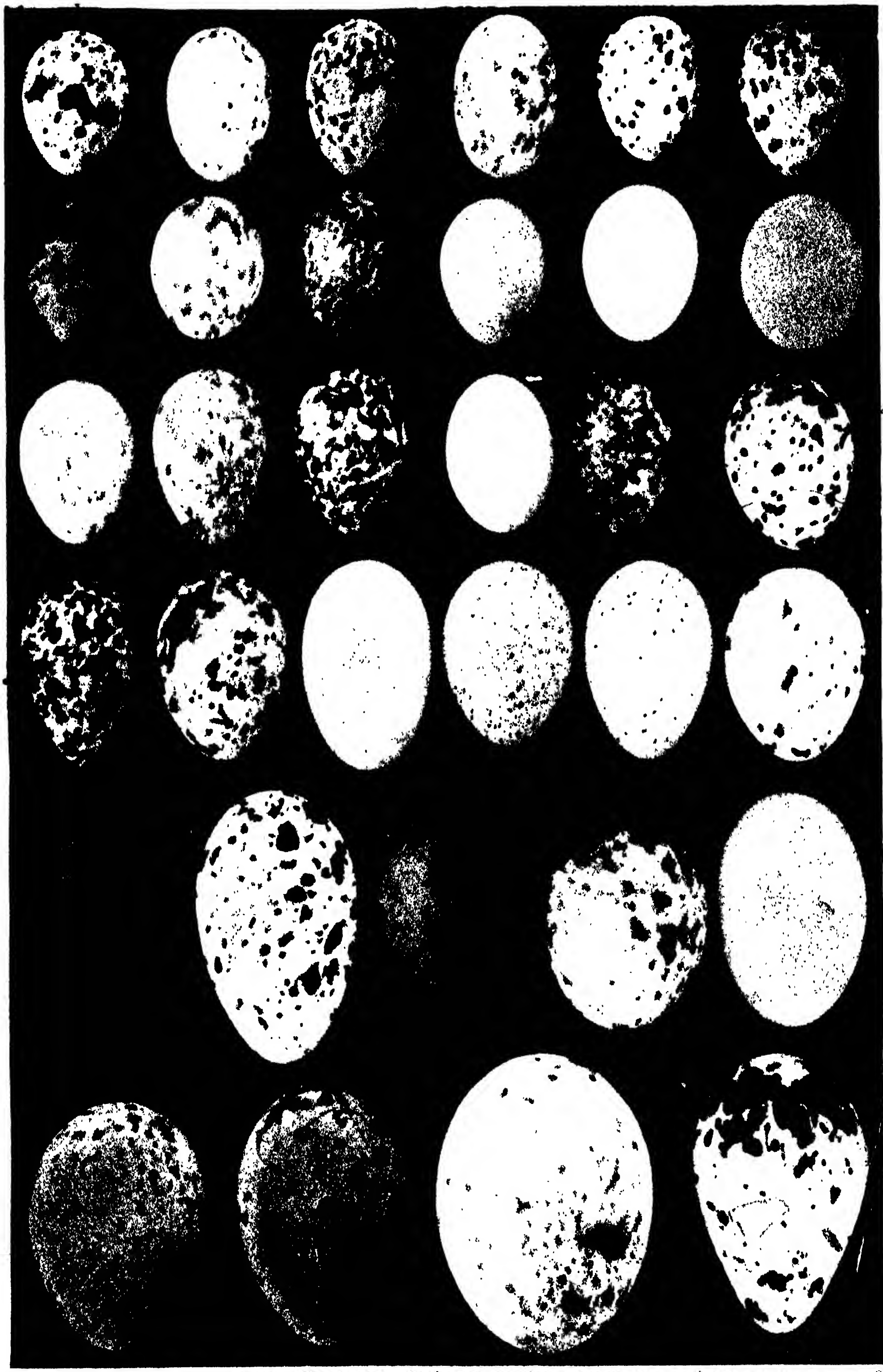
Group 24. Clerkship

Accountancy. Complete Training. Bookkeeping.
Shorthand. Pitman's System, with Latest Improvements.
Typewriting. Working and Management of All Machines.

Group 25. Mathematics

Arithmetic. Algebra. Simple Graphs. Euclid. Trigonometry.

THE EGGS OF THIRTY-THREE BRITISH BIRDS



... **First row** Arctic tern, moorhen, common tern, sand-grouse, rose... ...afl.

The Part Played by Honesty, Truthfulness, and Faithfulness in Inspiring Confidence.

THE WINNING OF CONFIDENCE

THE degree of confidence a man can win and keep is one of the most accurate measures of his true success, from boyhood to the end of his career. He appears on the scene first, let us suppose, as an office-boy seeking an engagement in connection with some business which he thinks will interest him. Whether he is engaged or not will almost certainly turn on whether he establishes, by his appearance, bearing, and recommendations, a preliminary and tentative feeling of confidence, a strong supposition that he will prove trustworthy.

In due course his service creates a firmer sense of confidence, and more and more responsibility is placed upon him. Within certain limits it is fully understood he can be relied on to do the work assigned to him. Then the confidence broadens, and there comes a time when it is felt that he can be made the repository of more intimate business confidences. He is now something more than a routine worker. He is in touch to some extent with the mind of the business. And last, it may be, he becomes a confidential servant; perhaps "another self" to the controlling mind of the enterprise. And so deepening degrees of confidence have been a kind of measuring rule for his career. How can this all-important progressive confidence be won and kept?

A moment's reflection will convince us that a complete sense of confidence must be a very complex creation, to which at least ten or a dozen qualities contribute. For example in business—which is the sphere we have specially in mind—industry is an essential feature. A man may have a score of good qualities, some of them so charming that he is beloved, but if he cannot, or will not, apply himself to routine work when it is expected of him, he will not inspire confidence. Men of great force of character have often allowed their life's work to be undermined by needless anxieties from sheer lack of the ordinary spirit of industry. Lord Palmerston is said to have once allowed war to break out between two European countries through his negligence in opening despatches when he was acting as an intermediary, and an ambassador declared that he had read eight volumes of "Clarissa Harlowe" in the ante-room of the Foreign Office while waiting for the same Minister to keep his appointments.

With industry, in the ordinary affairs of the world, honesty goes hand in hand. Without it, confidence is unthinkable. Simple as honesty is, it is really one of the most tantalising of all the primary virtues. To the right-minded man, a departure from honesty is inconceivable. It uproots all responsibility, brings complete chaos, and by its meanness probes the depths of dishonour. The dishonest Western man can have no moral fibre. Dishonesty and confidence are as antagonistic as an acid and an alkali. It is impossible that anyone can think of the conditions under which confidence is sustained without seeing that honesty is absolutely essential.

And yet the most amazing instances of a want of honesty occur within every man's experience. You can hardly bring together two hundred people by any process of selection, for any purpose, however noble, or to pursue any career, however exalted, without having among them a thief. No reasoning, no moral considerations, no sense of expediency, no worldly wisdom will prevent that man from being dishonest. He is born unworthy of confidence, morally a "freak," and he will be a failure and a disgrace sooner or later. This type, of course, is a rarity, and it is only mentioned here because its existence should be known and acknowledged as a mathematical certainty, within certain limits. Honesty, unquestioning and impregnable, is one of the foundation-stones on which confidence is built up.

A third corner-stone is truthfulness. Truthfulness is the positive side of honesty; that is, it is honesty taking the aggressive. To be materially honest, as with money, is not to do wrong in appropriating what is not our own; but truthfulness, synonymous with intel-

lectual honesty, is much more than defensive. It asserts itself with a quiet fearlessness on behalf of what it feels to be right. No one whose word cannot be relied on can hope to win confidence. When we have these three qualities—industry, natural or acquired, instinctive honesty, and matter-of-course truthfulness—we have the foundations of a character that is extremely likely to inspire confidence, though more qualities are required for a balanced character.

There is, for example, fidelity to the people for whom, or with whom, a man is working. In these days of keen competition, particularly, absolute loyalty to the enterprise or business in which one is engaged is a condition of commanding confidence. Whole-hearted service is the only service worth having. In some positions this demand for unshaken fidelity exists long after the relation of employer and employed ceases. Take, for example, the duties of a private secretary. Every private secretary who is admitted to a large share of the confidence of any public man, or participator in great business interests, must know facts which he has no right to divulge when he has left the service of the man to whom he was secretary. This form of confidence should be permanently sacred. Just as it is never right to "go back on" a man who has been a friend, so fidelity in all honourable business relations should remain untouched by time.

Here we approach another qualification for receiving confidence—the power of keeping a secret. Every piece of business, from the smallest manufacture of some article of general utility, up to the most pregnant international diplomacy, has its needs for silence, and a runaway tongue shuts out vast numbers of men and women from all positions of trust.

A wider qualification than the capacity for being silent respecting other people's business is the positive endowment of discretion. The discreet man not only does not talk about business which the public has no right to understand, but he does not even allow the subjects which involve business confidences to be approached. He wards off all inferences by keeping at a distance from topics on which he might be "drawn." There is no deception in this. Round every business there is an area which may properly be regarded as trespass so far as either rivals or the casual curiosity of the public are concerned, and the discreet man, worthy of the confidence of his employer, knows how to keep this area from intrusion.

It is obvious, from the array of qualities already enumerated as essential in the man who is to command confidence, that he must be a man of all-round good sense and capacity, with power of giving efficient service if he is to press on to any considerable success. Men of very little ability may be industrious, honest, truthful, faithful, and silent, and so far be valuable servants, but when we begin to reach the region when an all-round discretion is required while activity takes the worker into the society of clever men, a substantial equipment of shrewd, strong sense, joint product of brain and character, is imperatively needed. With this good sense must go pluck, and there is, further, a vast advantage in a full share of self-confidence, sturdy, but unobtrusive.

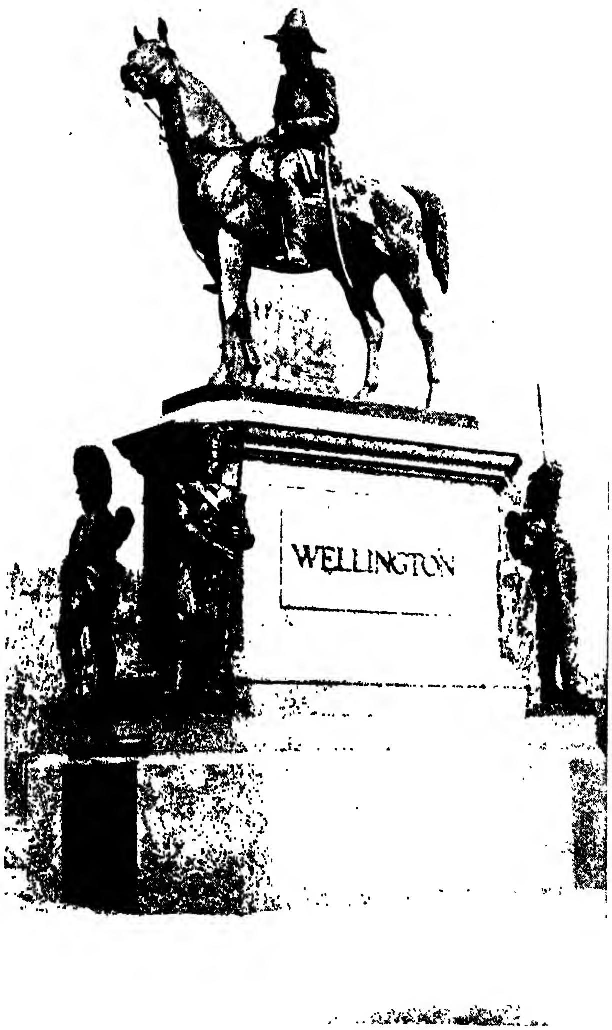
Let us look a moment longer at these two last points—pluck and self-confidence. A man may have all the excellent qualities that have been named, and yet if he is timid, a shirker of a straight encounter, he will not command the confidence either of his employer or of those who have dealings with him. The moment a man shows fear he loses command of the situation. The man who is bold of heart without being aggressive or cocksure, who has enough confidence in himself to be open, frank, and to admit truths even if they tell against the case he is supporting, who is no mere shallow optimist, but holds with fairness and well-reasoned strength the views he is advancing, conquers quietly all weaker men. They have confidence in a man who has confidence in himself. "Trust yourself," said Emerson; "every heart vibrates to that iron string."

If the winning of men's confidence, when analysed, is found to involve so many virtues, how comes it that certain people seem to carry confidence by storm long before they can be tested in all the particulars referred to, such as industry or discretion? It must be admitted that there are men of this type. They show their best side instantly under the stimulus of appealing to strangers. They "strike twelve at once." But often the amount of confidence felt in them depends on how long you have known them, and is in inverse ratio to the duration of your acquaintance. The lesson they need to learn

is not how to win confidence, but how to keep it. They are very charming for a while, and then there emanates from them a sense of instability. You begin to find out weaknesses that were not expected, instead of discovering signs of strength that were not immediately apparent. And so confidence gradually slips away, and another acquaintance is added to the list of men who are not to be altogether trusted.

How does this lamentable state of things occur? That it is sometimes postponed is not remarkable, for the crises that really try men are only encountered at distant intervals. You may know a most assiduous worker for years before proof arrives that he is likely to fail you at a pinch. A certain proportion of very worthy people are like a ship that drags its anchors in a storm. They have anchors, and they put them out, but the anchors do not hold. They may be wanting in pluck, in resource, in insight, if difficulties of great and unknown dimensions gather round, and the limits of their efficient help become clearly defined.

One rather interesting and curious type is the man who always needs to be stimulated to do his best, and then will do it faithfully. He must be "cheered up" before he becomes soundly trustworthy. Very likely he is an amiable man, and ready to fall at once into slack ways. Or he may be a timid man, and instinctively shirk the battle, yet have such a confirmed conception of the part played by courage, or such a deeply rooted belief in some cause, that when he is told plainly that this is the hour when he must play the man he will do it, and be as faithful as men of greater natural bravery or a clearer original insight. No one can feel much confidence in him if he be left to follow his inclinations, for he will take the easy path without bothering as to its destination; but when he has been instructed and brought into line, and made to see the true bearings of the contest, he will be as sturdy a henchman as can be found. Everybody who has had intimate dealings with men engaged in public affairs, for instance, knows well the man who must be put on his mettle every time if he is to be trusted. And it is so in business. There are many men admirably faithful when they are well looked after, but, standing alone, are on a somewhat slippery slope.



THE DUKE OF WELLINGTON AT HYDE PARK CORNER

Of course, the relapse from being worthy of confidence to being unworthy of it comes most frequently through allowing the various virtues we have considered to be slowly undermined. The man who was industrious slackens in his work for a

variety of reasons, perhaps because prosperity causes a weakening of fibre; the fine instinct of faithfulness is sapped by seeing how common it is for men to be indifferent on the score of fidelity; even truthfulness may be tampered with by a desire to be usefully accommodating; and discretion and the power of silence may give way before the garrulity of increasing age. All these tendencies mean that the onlookers are gradually lowering their feeling of confidence in the man who is either degenerating or showing himself in his true character; and confidence has to be strenuously kept as well as strenuously won.

The simplest and surest way of losing confidence is to be a "blab." Certain men, and perhaps more women, cannot know anything which they do not tell. Any knowledge that would appeal to curiosity is to them an intolerable burden. If they do not unroll it before the eyes of the public they must hint at it, and give it away by giving themselves away. A remarkable instance of this is given in Mr. W. H. Hudson's charming book "Birds and Man." He tells how he went on an ornithological outing in a southern county with a band of enthusiasts, headed by a well-known man who occupied a foremost position in the county, and was, like the rest, keenly interested in the preservation of rare species of birds. As they walked and talked, Mr. Hudson inquired whether the Dartford warbler was known to still breed in the county, and was assured that it was entirely extinct. Shortly after another well-known local naturalist, who had overheard the conversation, drew Mr. Hudson aside, and explained to him that there were Dartford warblers in the county, and he could show him where they were, but they were obliged to conceal the fact from the president of their Bird Protection Society, as they knew that he could not refrain from talking about it, and thereby lead to the destruction of the birds they wished to preserve. In this case the society had an organised want of confidence in its garrulous president.

As an offset to the man who wins confidence too readily and fails to keep it, one may introduce the rather pathetic figure of the man who by his qualities deserves to command confidence, but does not look as if he did. Many who begin their career with a reasonable ambition find quickly that they are handicapped by the want of a good appearance, a sufficiently assured bearing, the power of looking the whole world in the face with self-possession and without aggressiveness; and this consciousness of not making the best of themselves weighs them down, particularly when they see more assertive but less competent people pass them in the race. This is a mental attitude that should be resisted to the utmost, for it must soon undermine self-respect. Once allow it to get the mastery, and you will have the air of a beaten man. After that you can only hope to win confidence by inches if you win it at all. Meekness is for inside spiritual use rather than for outside wear.

One way of studying the phenomenon of human confidence, universally given and lastingly retained, would be to take the most conspicuous example from history. Who could be chosen? Could there be a more perfect instance than the great Duke of Wellington found in any land or age? His life was passed as a centre of controversy. His chief difficulty as a soldier was not that he had to struggle against the might and magic of Napoleon, but that at almost every stage he was harassed by political dissension while he was fighting the battle of Europe against the unscrupulous military tyranny of the French usurper. His later life was passed in the very centre of national strife, and his personal sympathies were all against the successful movements of the second quarter of the nineteenth century, and yet, at all times, he commanded the confidence alike of the men who agreed with his views and the men who detested them; and when he died the sense of loss of a man who had been trusted by everyone was overwhelming.

It may be questioned, indeed, whether history affords another instance that is quite so complete in its universality. There was a massiveness in Wellington's sense of duty, in his magnificent disinterestedness, in his fearlessness, that was a strength and comfort to every member of his race.

> Rich in saving common sense,
> And, as the greatest only are,
> In his simplicity sublime.

This supreme example of national confidence was built firmly upon Wellington's essential qualities of character, all of which centred on the idea of duty; and in every department of human activity a willing submission to that idea may draw upon us a confidence that will light our way to success.

JOHN DERRY

The Trans-Siberian Railway. Russia on the Pacific. Caucasia and its Oil. Arabia, Persia, Afghanistan, and the Borders of India.

RUSSIA IN ASIA

The ever-growing Empire of Russia in Asia includes the vast region of Siberia, the maritime district of Amuria, bordering the Pacific, Transcaucasia, or the highlands between the Caucasus and the Armenian highlands, and Transcaspia or Russian Turkestan, the steppelands east of the Caspian.

Siberia. Siberia resembles Russia in configuration and climate. It is a vast plain, equal in area to the whole of Europe, rising in the south and east to the highlands of Central Asia. These give rise to great rivers—the Ob, with its tributaries, the Ishim and the Irtish; the Yenisei and the Lena, which flow north across Siberia to the Arctic Ocean. They flow through highland scenery in their upper courses, emerge into the steppes at their northern base, cross the taiga, or primæval forest, and then creep sluggishly across the tundra to the sea, which they enter by great, marshy estuaries. All are ice-bound for months in winter, and great floods occur when the frost breaks up in spring. Navigation is important only during the short summer, and settlement along the rivers is proceeding somewhat slowly.

The climate of Siberia is everywhere extreme, especially in the east, where the northern limit of cereals is nearly 10° farther south than in Western Siberia. The summers are hot, especially in the east. In Eastern Siberia barley can be cut two months after sowing.

A Country of Vast Natural Resources. The natural resources of Siberia, though as yet little developed, are very great. The rich, black earth of Russia is continued into the steppes of Siberia, which are destined to become one of the great wheat-lands of the world. Russian authorities claim that nearly all the land south of 60° N. will be found suitable for cultivation when the forests are cleared and the marshes are drained. Wheat is grown on the richer and other cereals on poorer soils. Stock-keeping and dairy-farming are extremely important both in the steppes and in the rich meadows. In the forest clearings meat and butter of excellent quality are important exports. At present much of the richest land is too far from markets to be profitably used, but with better means of transport the prosperity of Siberia will increase rapidly.

North of the agricultural zone are the forests, rich in fur-bearing animals, and possessing in their timber a source of permanent wealth. Minerals, including gold, are abundant in the highlands, but coal seems to be scarce, and wood is the chief fuel even on the railways. Population is still scanty. Towns are few, though new ones are springing up at central points of communication with a rapidity equalled only in the Western United States. All are distinguished by a combination of show and squalor, fine hotels and cafés lighted with electric light opening on to unpaved streets resembling muddy lanes. Most of them lie on or near the Great Siberian Railway, the first sod of which was cut by the Tsar in 1891.

The Trans-Siberian Railway. A few miles beyond Zlatoust, in the Urals, with small-arms factories, the train enters Asia, the spot being marked by a finger-post, pointing west to Europe and east to Asia. Chelyabinsk, the first important station, which has rapidly grown from a small posting-station into a large town, is the junction of a line to Ekaterinburg, which joins the line to Perm and St. Petersburg. For nearly a thousand miles the line crosses an almost treeless plain, dotted with occasional birch clumps, and chiefly devoted to cattle-rearing. The stations are some 20 or 30 miles apart, and generally some distance from the town or village from which they take their name. Towards the end of the second day the traveller begins to notice the Kirghiz inhabitants of the steppe, either riding after their flocks and herds or even taking their seats in the train. They are dressed in long, sheepskin coats, with high, red leather boots and fur-trimmed caps, and their bowed legs tell of a life spent in the saddle. The towns of Kurgan on the Tobol, Petropavlovsk on the Ishim, and others are seen in the distance, and at last the train reaches Omsk, on the Irtish, the capital of the steppes. Omsk is in a sense the boundary between East and West.

East of Omsk. From places east of Omsk, wheat, barley, rye, oats, meat, skins, and even dairy produce, trend eastward, to supply the needs of newer settlements, but from Omsk they begin to flow west, to St. Petersburg and Moscow, northward by the rivers to the Arctic ports, southward to Odessa, and by caravans to Central Asia. The Ob is crossed by a bridge half a mile long, some 60 miles above Tomsk, a university town, which is reached by a branch line. Trees now become more numerous, and soon the train plunges into the forest, through which it runs for hundreds of miles to Krasnoyarsk, on the Yenisei, in the centre of a mining district.

The land is now steadily rising to the highlands round Lake Baikal, 42 miles west of which, on the Angara, is Irkutsk, the largest city of Siberia, which is reached on the fourth day after leaving the Ob. It has fine buildings, excellent technical and other schools, and important gold-smelting works. Beyond Lake Baikal the line runs through varied scenery to Chita, the capital of Transbaikalia, near which a branch diverges to the Amur Valley. The main line continues south-

east into Manchuria, and reaches Harbin, in the centre of a district whose fertility amazes every traveller. "Masses and masses of millet extend mile after mile as far as the eye can see, occasional clumps of trees looking like little green dots in a bronze-brown sea, and the villages themselves being half buried in the surrounding crops." From Harbin the traveller can go east to Vladivostok, or continue his journey south. For two days and nights he steams through crops such as are in all probability to be seen nowhere else in the world, passing Mukden, the capital, and reaching his journey's end on the shores of the Pacific, at the great military and naval base of Port Arthur. From Mukden lines run south to Peking and through Korea.

The Siberian Line in Winter. In winter all the traveller sees is leagues of snow on every hand, half burying the scattered villages. "Water for the stoves and the train has to be brought hot, lest it should freeze on the way, and men at the stations have to chop off long icicles from the train." This gives some idea of the difficulties Russia has to meet in opening up her Siberian provinces. On the other hand, the intense cold makes it possible in winter to transport meat and dairy produce for long distances without refrigerating-cars, which are necessary in summer. Sledge travel is easy over the hard snow, and at Petropavlovsk the traveller just quoted saw the strange sight of sledges drawn by camels setting out for Tashkend in Turkestan.

ASIA—THE SYMBOLICAL SCULPTURE ON THE ALBERT MEMORIAL IN LONDON.

The southern steppes of Siberia on either side of Lake Balkash and in the basin of the Upper Irtish are much hampered by the dry and extreme climate. Sandstorms devastate the country in summer, and blizzards in winter. The chief occupation is the rearing of live-stock—sheep, horses, cattle, camels, and goats. The largest town is Semipalatinsk, on the Irtish, communicating by that river with Omsk, on the Great Siberian line.

Russia on the Pacific. The Pacific slope of the continent is Russian from Kamchatka to the Korean frontier. The mountainous peninsula of Kamchatka, with snow-peaks as high as the Swiss Alps, has a dozen active and many extinct volcanoes. The winters are long and cold, the summers short and not warm. A little agriculture is possible in the interior, but for the most part the inhabitants are occupied in hunting for animals and in fishing. The richest part of Pacific Russia is the basin of the Amur, which separates Russia from China. This river (2700 miles) gives a route to the Pacific opposite the mountainous island of Sakhalin, now partly Japanese, while its right bank tributary, the Sungari, has greatly aided Russian designs on Manchuria and a warm-water port, the latter frustrated by the loss of Port Arthur. Blagovestchensk, with 80,000 people, the administrative centre, has steamer communication with Stretensk in Transbaikalia, Nikolaievsk, the port of the Amur, and Lake Khanka, a feeder of the Usuri, a right-bank tributary. The Amur is closed by ice from November to April, as is also Vladivostok, Russia's magnificent harbour and naval station in Southern Amuria. Agriculture in the rich valleys of the Zeya and Bareya, left-bank tributaries, gold-mining in the Stanovoi highlands, hunting in the great forests, and fishing in river and sea are the occupations of a scanty population living in villages some 20 miles apart.

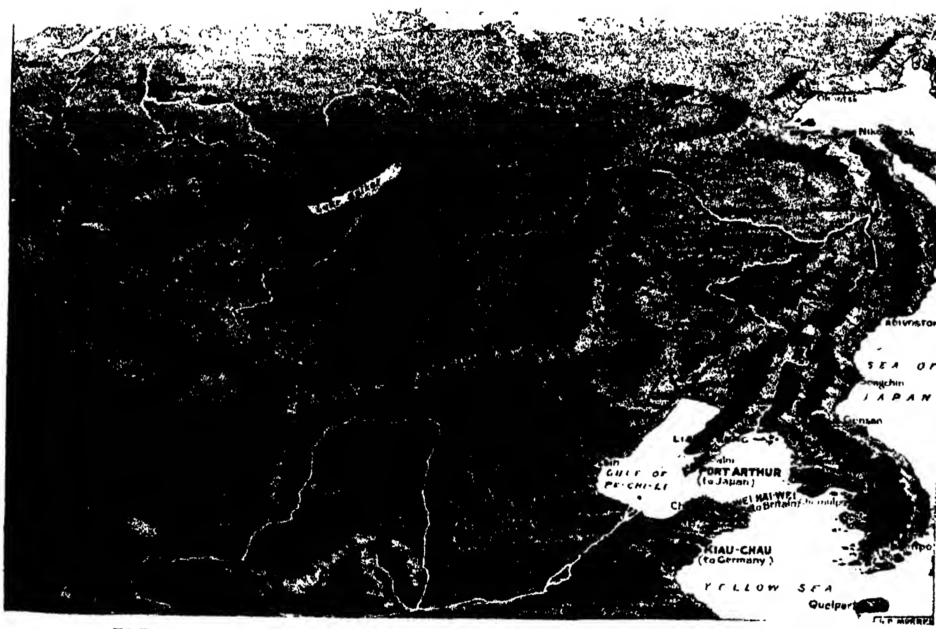
Caucasia. Caucasia occupies the isthmus between the Black and Caspian Seas; Batum and Poti being ports on the former, and Baku on the latter. North of the Caucasus, with Elburz rising to 18,000 ft., are the high steppes of the Terek basin, engaged in agriculture and cattle-breeding. South of the Caucasus is the rift, drained west to the Black Sea by the Rion and east to the Caspian by the Kur, with the capital, Tiflis, finely situated in its middle gorge. Both are rich valleys, growing mulberry, vine, maize, and a number of other fruits and cereals.

South of these valleys the land rises to the Armenian plateau, which is separated from Persia by the deep valley of the Araxes. The summers are everywhere hot, but severe winters are experienced in the highlands. The rainfall is heavy in the west and extreme south-west, but much of the east is arid. The cultivation of cereals, cotton, vine, and tobacco are important, with cattle-rearing in the higher pastures, but the richest asset is the petroleum region around Baku.

An Oil City. Baku is built on the shores of the Caspian, and has been described as follows: "If there were no oil, there would be no Baku. In addition to the Baku of lofty houses, good shops, and spacious streets, there is Black Town, where thousands of tons of crude oil are daily reduced to kerosine, benzine, lubricating oil, and residues for fuel. There are vast forests of derricks, under which are carried on those operations of boring and pumping which disgorge the

THE OPENING UP OF THE NEAR AND FAR EAST

THE TURKISH EMPIRE, SHOWING THE ROUTE OF THE BAGHDAD RAILWAY



• THE TRANS-SIBERIAN RAILWAY AND ITS BRANCHES IN THE FAR EAST
These maps are reproduced from the series issued by the "Review of Reviews"

wealth-bringing oil from the bowels of the earth. Balakhani, with its 2000 derricks, packed as close as trees in a forest, is one of the weirdest sights I ever beheld.

"I stood and watched the rich, dark green fluid, with its pink, glittering froth, being discharged by the great baler of one of the borings, an implement which raises upwards of 100 tons of oil a day. A spouter often blows the derrick to matchwood, but it throws up anything from 7000 to 10,000 tons of marketable oil, worth from £350,000 to £500,000, in 24 hours."

An Inflammable Region. The soil of this region is so logged with petroleum that inflammable gas is constantly escaping from the surface. It is literally possible to set the Caspian on fire in places, and, by poking a stick into the ground, to set free enough gas to light a flame several feet high. Baku oil goes all over Europe and Asia, and gives Russia a cheap fuel for the Caspian and Black Sea steamers and the railways on either side of the Caspian.

Russian Turkestan. The Russian possessions east of the Caspian and south of Siberia consist of waterless deserts of sand round the Caspian and the Sea of Aral, passing into steppes as the land gradually rises towards the mountains of Central Asia. The region forms an immense basin of inland drainage. The great Amu Daria and Syr Daria flow to the Sea of Aral, while others flow to Lake Balkash and smaller lakes. Where irrigation from any river is possible, an oasis—large or small—can be made, in which cereals, fruits, and cotton grow luxuriantly. Russia is devoting great attention to the cultivation of cotton in her Central Asian possessions. It is the staple product of Ferghana, the fertile region at the base of the Tian Shan, watered by the Upper Syr and its feeder, the Naryn. Here are situated the chief towns of Russian Turkestan, linked by the Transcaspian line with each other and with Europe.

The Transcaspian Railway. The traveller starts from Krasnovodsk, on the Caspian, a desert town which distils all its water from that brackish sea. For many hours the train runs across the desert between low hedges of sand-loving plants, planted to prevent the sand drifting deep over the rails. At long intervals it passes Askabad, near the Persian frontier, and Merv, created by the Murghab, which consequently runs dry before it reaches the Amu or Oxus, both oases in an all-surrounding sea of sand. The Oxus is crossed by a bridge a mile long, and the train plunges across the desert to Bokhara, which owes its fertility to the innumerable canals into which the Zerafshan is diverted.

The country gradually becomes less arid towards Samarkand, on the Zerafshan, once, like Bokhara, a world-famous centre of Mohammedan learning, and still with some fragments of its former splendour. The line now enters the Ferghana region, watered by the Syr and its tributaries from the south, and passes Andijan, in the centre of the cotton country, Chernayeve, the junction for Tashkend, the chief city of the Upper Syr, Khokand and Marjilan. From Tashkend a line runs across the Khirgiz steppes to Orenburg, where it connects with the European network. A line is projected to the wheat districts of Siberia that Ferghana may obtain cheap food, and devote its rich soil exclusively to growing cotton for the Russian textile industries.

Turkey in Asia. Asiatic Turkey lies west of a line drawn from the eastern end of the Black Sea to the Persian Gulf. Much of the surface consists of highlands with valleys which are fertile under irrigation, but lapse into desert where this is neglected. Of the famous cities of Greek and Scriptural history little remains but the name, and the whole region is in a backward and neglected condition. The great peninsula of Asia Minor, separating the Black Sea from the Levant end of the Mediterranean, is a plateau averaging 3000 ft. in height, but much higher in the south, where the Taurus Mountains rise to nearly 10,000 ft. The famous pass of the Cilician Gates leads down to the fertile plains of Adana, watered by the Jihun and Seihun, and growing much cotton. The port is Iskanderun, in the angle between Asia Minor and Syria. On the plateau sheep and goats are kept, the wool and hair being made into carpets, and the skins into leather. In the valleys wheat and vines are grown, and dried raisins and figs are important exports. The ports are Trebizond, Samsun, and Sinope, on the Black Sea, and Smyrna on the Mediterranean.

Turkish Armenia. Turkish Armenia lies east of Asia Minor. The capital is Erzerum, a centre of caravan trade, on a fertile plain watered by the Kara Su branch of the Euphrates, which rises in the Armenian highlands. The elevation makes the winter severe on the pastoral highlands, while in the valleys, where cotton, tobacco, cereals, and fruits are grown, the summers are intensely hot.

Mesopotamia. The Euphrates, which, with its tributary the Tigris, drains the Armenian highlands south to the Persian Gulf, has its upper course in picturesque defiles through the highlands. It then enters the alluvial plains of Mesopotamia, once the garden of the world, and the seat of the famous power of Nineveh and Babylon. The whole of this region has lapsed into a bare waste, with indifferent pasturage, where a scanty population ekes out existence on lands which once fed millions. Baghdad on the Tigris, once the centre of all commerce between the Mediterranean and the Persian Gulf, has still considerable trade. Excellent dates are grown round the Persian Gulf and exported from Basra. Large irrigation schemes are projected, and a railway from the Asia Minor lines is being built to the Persian Gulf.

Syria and Palestine. West of the Euphrates lies the Syrian desert, continued south by that of Arabia. The Mediterranean littoral of Syria and Palestine receiving winter rains has been, and might again be, extremely fertile, producing all Mediterranean fruits and cereals. East of the Lebanon mountains are Aleppo, on the trade route from the Persian

Gulf by the Euphrates towns to Iskanderun, and Damascus, the capital of Syria, and one of the oldest cities in the world, a green spot on the edge of the desert made fertile by the Abana. Haifa and Beirut, in Palestine, are ports on the Mediterranean. Jerusalem, the capital of Palestine, west of the Jordan, which flows to the Dead Sea, is sacred to Christians for its religious associations. A railway follows the pilgrim route from north to south, and lines join Damascus to Haifa and Beirut, on the Mediterranean. A railway also joins Jerusalem to the port of Jaffa.

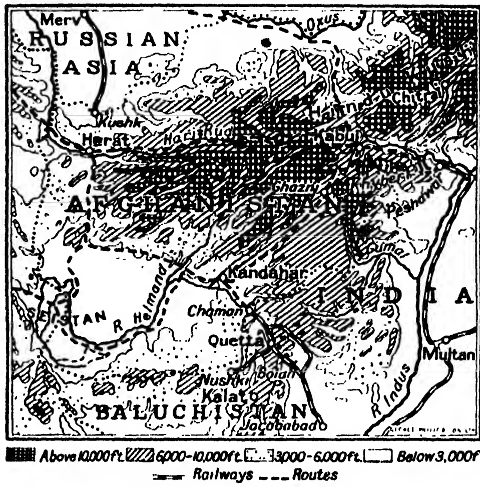
ARABIA

The tableland of Arabia, averaging 3500 ft. in height, rises to 10,000 ft. in the south-east, and is only 1000 ft lower in the peninsula of Sinai in the north-west. It is one of the driest regions in the world, with cold winters in the higher parts and hot summers. Much of it is sandy or stony desert, but those valleys which have running streams are very fertile. The date is widely grown, and coffee, gums, and spices are produced in the fertile parts of Southern Arabia. Where pasture is good, the keeping of animals is very important, and the horse and camel are closely bound up with the life of the Arab, who is still a wanderer, dwelling in tents, which are made from the wool and hair of his flocks by the women of his family. The ports are Jeddah and Hodeida, on the Red Sea, and Oman on the Persian Gulf. Pilgrimages are made to Mecca and Medina, which are to Mohammedans what Bethlehem and Jerusalem are to Christians. Aden, in the extreme south-west, amid burnt-up surroundings, is British. Much of Arabia is ruled by independent native chieftains.

PERSIA

Persia (628,000 sq. miles) is a plateau 6000 to 7000 ft. high, sinking steeply to the Caspian in the north, and to the Persian Gulf in the south, with narrow coastal plains along these seas. The northern margin of the plateau is formed by the Elburz Mountains, with Demavend (18,000 ft.) and other lofty peaks. In the extreme north-west, on the Armenian frontier, is Ararat, almost as high. Most of the surface of Persia is treeless, and there are large areas of salt desert. The rivers are short, and few reach the sea. The climate is extreme and the rainfall scanty. Snow falls on the western mountains in winter, and, melting in spring, fills the dry river-beds, supplying water, which is distributed by underground canals to prevent loss by evaporation, for the purpose of irrigating the lands round the villages during the hot, rainless summer. These villages make little islands of verdure in the brown, parched landscape. In their orchards ripen the vine, olive, peach, apricot, nectarine, pomegranate, fig, almond, and other fruits equally delicious. In the valleys of the north-west wheat grows ripe up to 9000 ft., and rice is much cultivated around the Caspian. Cotton is also grown. The staple products, however, are wool and hair. Persian rugs and carpets are famous all over the world.

Persian Towns. The towns of Persia are often separated from each other by many days' journey over mountain and desert. As might be expected in such a country, the roads are few and bad. From Resht, the Caspian port, a route climbs the wet, forested northern slopes of the Elburz to the dry, arid southern slopes, at the base of which, on the plateau, is Teheran, the capital. Another important northern town is Tabriz, in the region of salt lakes, south of the Aras. Kermanshah, further south, trades with the Euphrates towns. On the Persian Gulf are Bushire, Bandar Abbas, and other ports. Ispahan, Yezd, Kerman, and Shiraz, with its rose-gardens, are inland towns.



THE FRONTIER OF INDIA

Near the Russian frontier is Meshed, which could easily be connected by rail with the Transcaspian line.

AFGHANISTAN

Afghanistan is a higher, bleaker land than Persia, rising towards the lofty Pamir plateau, the Hindu Kush, and the Suleiman Mountains. The climate is extreme. In summer the valleys are intensely hot, and two harvests can be reaped—one of wheat, barley, and lentils, in spring, and one in autumn of rice, cereals, fruits, and tobacco. The roads are of the roughest description, and the camel the only pack-animal. The people are hardy, fierce mountaineers, whose main occupation is the keeping of animals on the pastures of their steep mountain valleys, down which rush the torrents fed by the snows of the mighty mountains above. Those flowing north find their way to the Oxus; the Kabul River flows east to the Indus.

The route from India, after traversing the Khaibar Pass, follows this river to Kabul, the capital of Afghanistan. The Helmund flows west by Kandahar to the more arid portion of the country, losing itself at last in a lake of considerable size. Farther north is the Hari Rud, with Herat, to which a branch of the Transcaspian line is projected.

A. J. AND F. D. HERBERTSON

A First Lesson in Object Drawing. Measuring. Light and Shade. First Principles of Perspective. Instruments in Practical Geometrical Drawing.

MODEL DRAWING & GEOMETRY

Model or Object Drawing. When a person wishes to make a drawing of any real object, he has many difficulties confronting him, which he did not have in freehand from the flat copy. He has now to give the representation of an object in the "round," on a flat surface of paper or canvas. Therefore his perceptive faculties will need still further careful guidance with reference to *how to see* an object, whether it be its apparent form, tone, or colour.

At present we shall deal chiefly with the apparent *form*, leaving tone and colour until the student is more advanced. It will be noticed that we have spoken of the *apparent* form of an object, and this is the first great stumbling-block to all beginners in object drawing. They so very often draw the *real* instead of the apparent shapes, and then cannot understand why their drawing does not appear like the object. There are so many optical illusions with regard to the appearance of an object, that, without a thorough method of explanation of *how to see*, the student is bewildered and sometimes gives up in despair.

Two Important Rules. There are several rules which will be helpful, but the two most important are:

1. Draw the *apparent* shape of an object, and not what you know is the *real* shape. Occasionally it happens that the *apparent* is the same as the *real* shape of an object, but still the above rule holds good.

2. In any objects, those edges which are *really parallel* to one another, and *recede from the spectator*, always appear to converge to some point.

For explanation of the first rule we will take a circular hoop made of thin stiff wire, so that we can neglect its thickness. If the hoop be placed in a horizontal position on a level with the eyes, the student will see an appearance like *AB* in **17**. That is, a *straight* line must be drawn for the representation of a circle in such a position. This, to a beginner, is incredible at first, but he can easily prove that the apparent shape of the circle is a straight line, by holding horizontally, and on a level with his eyes, the straight edge of a ruler between his eyes and the object. He will observe that the real curve of the hoop *appears* to lie exactly straight and level with the edge of the ruler.

If the hoop be placed still in a horizontal position, but this time *below* the eye level, the student will see a shape like the ellipse *CFDE* in **17**. Here the distance *EF* is *apparently* much less than *CD*, but in *reality* they are equal. When the hoop is placed further below the eye, and still in a horizontal position, an ellipse of different proportion is seen as indicated in *GLHK* in **17**. Again placed in a horizontal position, but *above* the eye level, an ellipse like *MPNO* will be seen. Moreover, if the distance above the eye level is just the same as that below, and the hoop is exactly the same distance from the observer, this ellipse *MPNO* is the same size in every respect as the ellipse *CFDE*; but it must be remembered that the apparently upper curve *MON* now represents the *nearer* part of the loop, and *MPN* the *further* part, whereas, when below the eye level, *CFD* represents the nearer part, and *CED* the further.

If the hoop is placed higher still and horizontally, an ellipse like *QTRS* will be seen, and this will be exactly the same size as *GLHK*, if the respective distances, above, below, and from the eye are kept equal in each position. The student should also observe that the major axes *AB*, *CD*, *GH*, *MN*, and *QR* are always the same length, at whatever level (within the field of vision), if the hoop is placed at the same distance from the spectator, but the minor axes vary in length. The general tendency of all beginners is to make these minor axes too long.

The Cube. We will now take a cube as an example for more fully explaining the first rule. It is well known that each of its six faces is *really a square*, but it is, of course, quite impossible to see all these faces as squares at the same time; in fact, if we use an opaque cube, we cannot see, at the same time, more than *one* face as a *square*, and this only in a particular view. More often all the visible faces are nearly, but not quite, parallelograms. Look at **18** (which is the correct representation in outline of a cube when viewed from a particular point), and it will be seen that the faces *B* and *C*, more especially *A*, are not *squares* in this representation, for the angles are not right angles, the four sides of each surface are not equal, nor are certain pairs of opposite sides parallel. That is to say, by drawing the *apparent* shapes of *really* square surfaces, we obtain, as far as outline alone can give us, the true appearance of the object.

A really square face may even be represented by a line only, as for the top surface of cube in **19**, which is the appearance of the cube when placed upright, so that its top face is exactly level with the eye. In looking at **20**, we do not, at first, realise that it is the representation of a cube, but it is the appearance of it when it is placed in a vertical position, and the student is looking at it so that a straight line drawn from his eye to the centre of the visible face of the cube would be at right angles to that surface. He can thus see only *one* face of the cube, which *appears as a square* in shape. The student should now study other different appearances of the cube in various positions, as shown in **21**, **22**.

and 23. The last figure is the appearance of the cube in a certain upright position *above* the eye level.

It often happens that a *short* line must be drawn for a *long* edge of an object, and a *longer* one for a short edge. Figures **24, 25, 26** and **27** are the outline representations of an ordinary drawing-board in various positions. In **25** and **27** it will be noticed that the *long* edges, *AB* and *CD*, of the board are drawn *shorter* than the *short* edges *AD* and *BC*. In certain positions these different edges may *appear* equal.

The eye is so easily deceived by what we *know* is the real length or size of an object, that our judgment is misled. Therefore we must have a means by which we can prove whether the judgment is correct or otherwise. The student must consistently persevere in first judging carefully with the eye alone, and afterwards test by measuring with a pencil held between the eye and the object. With regard to the method of holding the pencil for making tests, there are one or two important facts to be kept in mind, otherwise the test is worse than useless. The pencil must *always* be held at *full* arm's length, and at right angles to a line drawn from the eye to the object viewed.

Measuring an Object. To be convinced of the necessity of this, the student should hold the pencil as just advised, and measure on it the apparent length of some horizontal or vertical straight edge, which is at some convenient distance from the eye; then, remaining at the same distance from the object, let him bend the arm a little, so as to bring the pencil nearer the eye, and measure the same edge again. He will find that its apparent length is now shorter than it appeared before. Again, let him bend the arm a little more, thus bringing his pencil still nearer to the eye, and once more measure the same edge. It will be found to appear shorter still. Thus the apparent length of the edge, as measured by means of the pencil, varies according to the distance at which the pencil is held from the eye. Therefore if, consciously or unconsciously, he holds the pencil at different distances from the eye, when comparing the apparent sizes of objects, he is making useless tests at different scales of measurement, he has no fixed standard, and is making the same kind of mistake as would be made by a person drawing a map of England, and using a different scale for each county, beginning with Northumberland at the scale of one inch to a hundred miles, then Durham at three-quarters of an inch to a hundred miles, Yorkshire at half an inch to a hundred miles, and so on. The map, of course, would be worse than useless for judging the relative sizes of the counties or the distance from a town in one county to that in another.

It is very difficult to judge when the pencil is held at a *constant* distance from the eye when the arm is bent, but it is easy to know when the arm is at full stretch, and thus a fixed standard of scale is easily established for making accurate comparison of the relative sizes of objects.

Light and Shade. The light and shade, which must necessarily be visible in any object, is a frequent cause of deceiving the powers of perception. Take a shape as represented in **28**. This appears to be an oblong, and, of course, is one; nevertheless, it is also the apparent shape, in outline, of a circular slab, when placed horizontally and on a level with the eyes. Beginners, because they *know* the slab is curved at its edges, draw the representation as in **29**, which is *wrong*. If **28** is shaded, as shown in **30**, the roundness is at once noticed, and yet the actual outline in **30** is an oblong as in **28**. Colour, too, will often deceive the eye with regard to size. A very light-coloured object surrounded by others which are very dark seems to the eye at first to be larger than it is found to be when tested by measurement with the pencil, and, *vice versâ*, a dark one appears smaller. To give the representation of certain objects in outline alone is sometimes more difficult than when rendered by tone and colour, but still these difficulties will be overcome if the student perseveres with such helpful methods as are advised in this course.

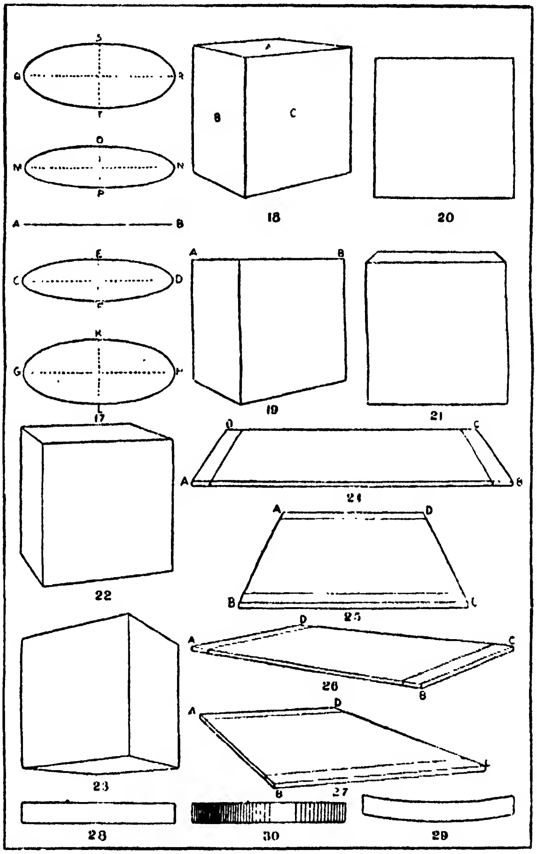
Perspective. When we consider the second important rule of object drawing, we are brought face to face with the subject of Perspective, the theory and practice of which is almost invariably unknown to beginners in drawing. There are many capable artists who say that the rules of perspective are better left alone, but this is often only an excuse for not taking the trouble or not having the desire to study Perspective. The general principles can soon be learnt, and after some practical application of them, all students would do well to go through a good course of study, in which they can learn and practise the rules used in the linear and aerial perspective of objects with their shadows and reflections. It is certainly true that those students, who go through such a course thoroughly, will not only be able to make much more accurate judgment of the appearance of objects, but will also know *why* they must be drawn in a particular way in order to render a true representation of them. We shall confine ourselves to the most essential principles of perspective needed by all beginners in object drawing.

Everyone who has seen a railway or tramway, especially if it is straight, must have noticed that the really parallel metals *appear to converge* as they recede; see **31**, which represents a portion of a railway. It will be seen how well a suggestion of distance is obtained by making the lines converge. Now look at **32** (which is an *incorrect* drawing of the same railway); here we get no suggestion of distance, and the metals, etc., seem to be standing on end with the bridge placed on top. This apparent convergence is true of all parallel edges *which recede* from the observer. Whether they recede straight away in front of him [**33**], or slant away towards the right or left, or even upwards or downwards away from him, as long as they are *receding*, they will be observed apparently converging to

some point, which is technically called "a vanishing point."

The First Principle of Perspective. Thus we deduce the first principle of Perspective—*edges which are really parallel to one another, and recede from the spectator, appear to vanish to the same point.* In some cases this vanishing point is difficult to determine (unless the student knows the whole theory of perspective), but all *really* horizontal edges which recede *always have their vanishing point somewhere on the horizon line.* This horizon line is always supposed to be on a level with the eye, and its position in relation to other objects can easily be determined by holding perfectly horizontal, at arm's length, a piece of flat cardboard, so that only its *edge* is seen. The student can then see where it appears to cut the objects in view, and by careful observation he will find that all receding parallel edges, which are really horizontal, appear to converge to some point on this horizon line.

Look at 33, where the edges of the frieze and wainscot of the right- and left-hand walls, the floor-boards, and certain edges of the door and one picture-frame appear to converge to the point *C.V.* (that is, the centre of vision, which is a point on the horizontal line directly opposite the spectator's eye). The edges *AB*, *CD*, *EF*, *GH*, of one door of the window vanish to the left to *V.P.* 1; the edges *JK*, *LM*, *NO*, *PQ*, of the other door vanish to the right to *V.P.* 2; the long edges of the table, and the dotted lines *ad*, *bc*, on the floor, vanish to the right to *V.P.* 3 (which is outside the limits of the picture); the short edges of the table and the dotted lines *ba*, *cd*, vanish to the left to *V.P.* 4 (which is outside the picture); in the lid of the box the edges *VY*, *RU*, *WX*, *ST*, vanish downwards to *V.P.* 5 (below the picture), while the edges *UY*, *RV*, *SW*, *TX*, vanish upwards to *V.P.* 6 (above the picture). It should be noticed that receding horizontal edges *above* the level of the eye appear to converge *downwards*, those *below* the eye level *upwards* to the horizontal line, while those exactly on the eye level, such as *ef* of the large picture, slant neither up nor down.



17-30. THE FIRST PRINCIPLES OF OBJECT DRAWING—DIFFERENT VIEWS OF CIRCLE, CUBE AND BOARD.

Parallel Lines. Particular attention should also be given to the representation of the edges of the frieze, the top and bottom of window-frame, the wainscot of the farther end of room, and also to the long edges of the box. It will be seen that *they do not converge,* but are drawn perfectly horizontal and parallel, *because they are not receding* from the spectator. Further, upright parallel edges must be represented by *upright* lines, with no convergence for the same reason; therefore, note all the upright lines in 33.

Keeping in mind the very important principles explained in the foregoing paragraphs, the student should now make many careful observations of objects around him, and endeavour to discern the difference between their *apparent* and *real* forms. He will then be well prepared to proceed in drawing some simple objects.

GEOMETRICAL DRAWING

What Geometry Is. The term *Geometry,* which is derived from two Greek words (*ge,* the earth, and *metron,* a measure), originally signified *land-measuring*; but it now denotes the science of magnitudes in general, with their various properties and relations. We here follow the *practical* side of Geometry, leaving the *theoretical* side to be explained in the course on Mathematics.

The student who possesses a knowledge of Euclid will have a powerful aid in understanding the principles used in practical geometry, and in remembering the methods of construction used in the various problems. We shall bring together those problems which depend for their solution upon some important geometrical truth, thereby not only training the mind to logical deduction, but aiding the memory.

Instruments Needed. The student should always work with the greatest possible accuracy and neatness, for inaccuracy and slovenliness will undoubtedly lead to disappointment and failure. Whatever instruments are used should be of the *very best quality,* in

order to avoid errors and vexation. The instruments need not be numerous, but the following are absolutely essential, and should be used for the purpose mentioned:

1. A half-imperial drawing-board and pins, with its adjacent long and short edges perfectly perpendicular to one another.

2. A T-square, which is used for drawing lines parallel to the edges of the board [**34**].

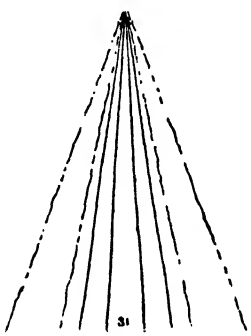
3. Two set squares, having respectively angles of 45° and 60°. These are used to obtain perpendiculars and parallels [**34**].

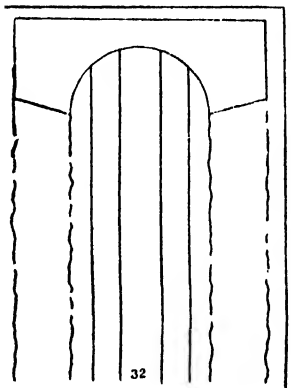
4. A pair of compasses with movable pen and pencil legs (those with needle points are best, as they do not make large holes in the paper).

5. A pair of dividers for measuring.

6. A mathematical pen for ruling lines in ink.

7. Two pencils, one HH for the construction lines, and the other HB or F for the darker lines of the figure. Sharpen them wedge-shaped.





31. CORRECT AND **32** INCORRECT PERSPECTIVE

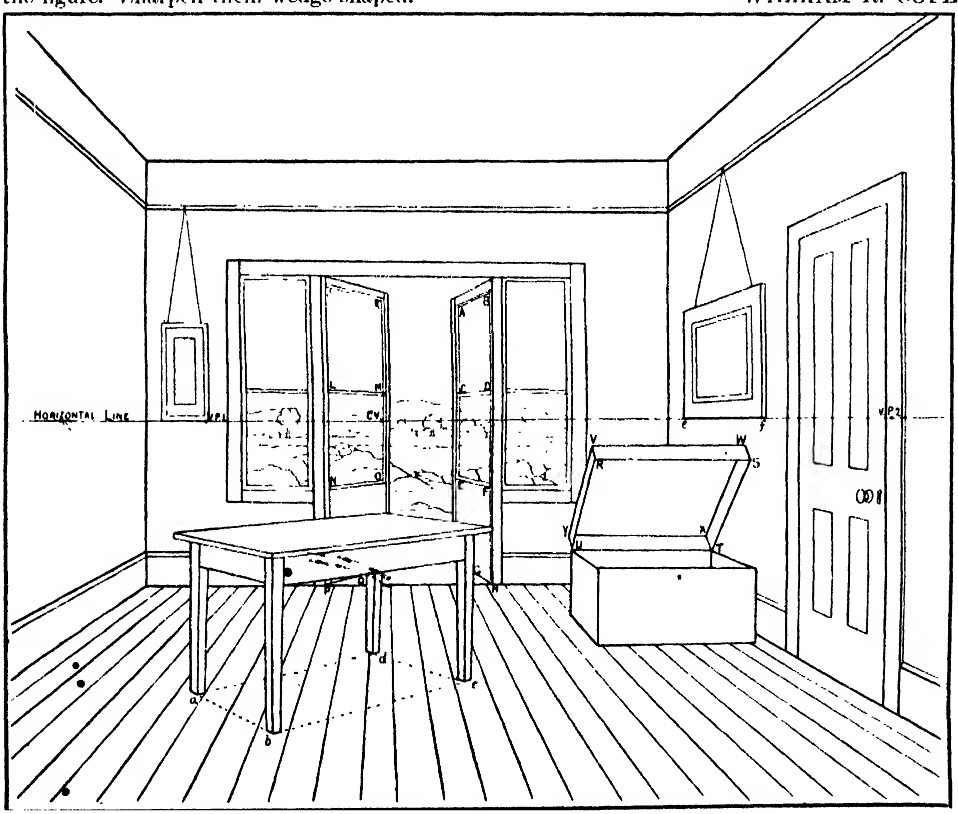
8. The paper may be cartridge for ordinary pencil work, but for inked drawings Whatman's or O.W.S. "hot-pressed" surface paper is best.

9. A protractor, either semi-circular or as a flat ruler; see **35**, which shows how one is marked from the other. This is used for measuring angles in the following manner: Suppose we wish to measure an angle of 50° at the point *A* in the line *AB* [**36**]. Place the point *C* of the protractor on the point *A*, carefully keeping the edge of the instrument on the line *AB*, and mark a point *D* opposite the division for 50°, remove the protractor, and draw a line from *D* to *A*, then *DAB* is the angle required.

10. A foot ruler, with tenths of an inch marked on it, as well as the usual divisions, and also centimetres and millimetres.

11. Some Indian ink (in liquid form is best). Ordinary ink corrodes the pens.

WILLIAM R. COPE



33. A STUDY IN PERSPECTIVE—THE INTERIOR OF A ROOM

A DICTIONARY OF ELEMENTARY TERMS IN PLANE GEOMETRY

The figures after definitions refer to the illustrations in this section

An **ACUTE ANGLE** is less than a right angle [44, EFG].
An **Acute-angled Triangle** has all its angles acute [53].
Adjacent Angles have a common vertex and one common arm. In **46**, the angle ABC is adjacent to ABD.
Altitude of Triangle. See **Triangle.**
An **Angle** is the inclination of two straight lines which meet in a point, called the **vertex** of the angle.
The size of an angle does not depend upon the length of the lines forming it, but upon their inclination to each other. In **42** the angle BAC is the same size as the angle DEF.
The sum of all the angles in any one triangle is equal to two right angles, or 180°.
Apex. See **Triangle.**
An **Arc** is any part [ACB in 64] of the circumference of a circle between any two points in it.
Area. See **Figure.**

BASE. See **Triangle.**
To **bisect** means to cut into two equal parts.

CENTRE OF CIRCLE. See **Circle.**
A **Chord** is a straight line joining any two points in the circumference of a circle [AB in 64].
A **Circle** is a plane figure contained by one curved line, which is called the **circumference,** or **periphery,** and is such that all straight lines drawn from a certain point within the figure to the circumference are equal to one another. This point [A in 63] is called the **centre** of the circle, and each of the straight lines [e.g. AB, AC, AD, AE in **63**] is called a **radius** of the circle. The straight line [e.g. CD or BE in **63**] drawn through the centre and terminated at both ends by the circumference, is called the **diameter,** which divides the circle into two **Semicircles;** and if two diameters are drawn perpendicular to each other, each of the four parts [CAB, BAD, DAE, EAC in **63**] of the circle is called a **quadrant.**
Circumference. See **Circle.**
The **Complement** of an angle is the difference between it and a right angle. In **45** the angle ABD is the complement of the angle DBC, and DBC is the complement of ABD.
Concentric circles are those which have the same centre but different radii [66].
A **Curved line** is a line that is nowhere straight [39].

DECAGON, a ten-sided polygon.
Diagonal. See **Quadrilateral Figure.**
Diagonal Scale. See **107-109**
Diameter. See **Circle.**
Duodecagon, a twelve-sided polygon.

An **EQUILATERAL TRIANGLE** has three equal sides [48].
Extreme and Mean Ratio. See **103.**

A **FIGURE** is a space enclosed by one or more lines or boundaries, as **47-65.** The sum of all the boundaries is called the **perimeter,** and the space within the perimeter is called the **area.**

HEPTAGON, a seven-sided polygon.
Hexagon, a six-sided polygon.
A **Horizontal line** is perfectly level [40 A].
Hypotenuse. See **Right-angled Triangle.**

IRREGULAR POLYGONS. See **Multilateral figures.**
An **Isosceles triangle** has two equal sides [49].

A **LINE** has length without breadth, and may be represented by various methods, as **thick, thin, dotted,** or **chain** lines [38].

MULTILATERAL FIGURES, or **polygons,** are figures contained by more than four straight lines [60-62]. **Regular polygons** have all their sides equal [61 and 62], and **Irregular polygons** have their sides unequal [60]. Polygons are divided into classes according to the number of their sides; as, the

- **pentagon** [61], having five sides;
- **hexagon** [62], having six sides;
- **heptagon,** having seven sides;
- **octagon,** having eight sides;
- **nonagon,** having nine sides;
- **decagon,** having ten sides;
- **undecagon,** having eleven sides;
- **duodecagon,** having twelve sides.

A **Median.** A line drawn from the vertex of a triangle to the middle point of the opposite side.

NONAGON, a nine-sided polygon.

An **OBLIQUE LINE** is a line that slants [40 C and D].
Oblong. See **Rectangle.**
An **Obtuse angle** is larger than a right angle [44, HKL].
An **Obtuse-angled triangle** has one of its angles obtuse [52].
Octagon, an eight-sided polygon.
An **Orthocentre.** The intersection of the perpendiculars from the corners of a triangle to the opposite sides.

PARALLEL LINES are such as are in the same plane and never meet though produced indefinitely, but always retain a uniform distance apart [41].
Parallelogram. See **Quadrilateral figure.**
Pentagon, a five-sided figure.
Perimeter. See **Figure.**
Periphery. See **Circle.**
Perpendicular. See **Right angle.**
A **Plane** is a level surface, and is such that, if any two points be taken in it, the straight line joining these two points lies wholly in that surface.
A **Point** has position only, without magnitude, and in practice is usually represented by a dot, as in **37.**
Polygons. See **Multilateral figures.**
A **Problem.** A proposal to do something, such as to solve a question, or to draw a figure, as in **86-103.**
A **Proposition** is that which is offered or proposed for adoption or consideration. Propositions are, in geometry, of two kinds, viz., **Problems** and **Theorems.**

QUADRANGLE. See **Quadrilateral figure.**
Quadrant. See **Circle.**
A **Quadrilateral figure,** or **quadrangle,** is contained by four straight lines, as the square, oblong, rhombus, and rhomboid [54-57]. If the opposite sides are parallel, it is called a **parallelogram** [54-57]. The line joining two opposite angles is the **diagonal,** as AB in **54.**

RADIUS. See **Circle.**
A **Rectangle,** or **oblong** ... site sides equal and all angles right angles [55].
Rectilineal figures are contained by straight lines, as **47-62.**
Regular Polygons. See **Multilateral figures.**
A **Rhomboid** has its opposite sides equal, but its angles are not right angles [57].
A **Rhombus** has all its sides equal, but its angles are not right angles [56].
A **Right angle.** When a straight line meets another, so as to make the adjacent angles equal, each of the angles is called a right angle, and the lines are said to be **perpendicular** to each other. In **43** the angles ABC and ABD are each right angles, and the lines AB, CD are each perpendicular to the other. It should be observed that **perpendicular** does **not** mean upright or vertical, but **at right angles to another.**
A **Right-angled Triangle** has one of its angles a right angle. The side opposite this right angle is the **hypotenuse** [AB in **51**].

A **SCALENE Triangle** has three unequal sides [50].
A **Sector** is a space enclosed by two radii of a circle [AB and AC in **65**], and the arc BC between them.
A **Segment** of a circle is the space enclosed by an arc and its chord [64].
Semicircle. See **Circle.**
A **Square** has all its sides equal and all its angles right angles [54].
A **Straight line** is the shortest distance between two points.
A **Superficies,** or **surface,** is extension in two directions, and has only length and breadth, but no depth.
The **Supplement** of an angle is the difference between it and two right angles. In **46** the angle ABD is the supplement of the angle ABC, and ABC is the supplement of ABD.

A **TANGENT** [A B in **66**] is a straight line which touches a circle or curve at one point [C in **66**] but does not cut the circle or curve when produced. A tangent to a circle is at right angles to the radius.
A **Theorem.** A proposition to be proved by reasoning.
A **Trapezium** has none of its sides parallel, but two may be equal [59].
A **Trapezoid** has only two sides parallel [58].
A **Triangle** is a figure contained by three straight lines. The side upon which it stands is termed its **base;** the point where the other two sides meet is its **vertex,** or **apex;** the angle at this vertex is the **vertical angle;** and the straight line which is drawn from the apex perpendicular to the base or the base produced is called the **altitude.** Thus in **47,** if BC be the base, then A is the vertex, BAC is the vertical angle, and AD is the altitude. Triangles are named, with reference to their **sides:**

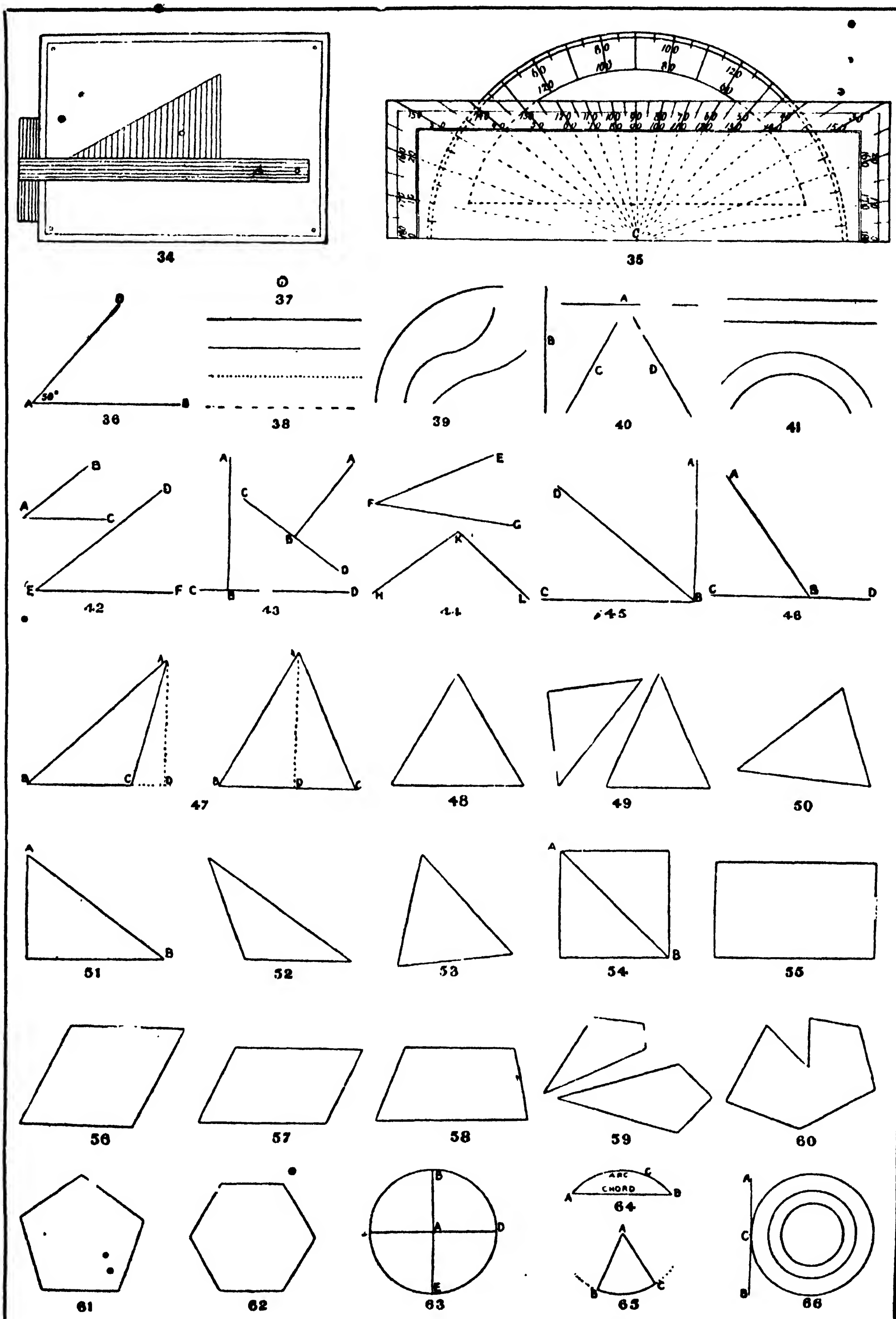
1. **Equilateral,** having three equal sides [48];
2. **Isosceles,** having two equal sides [49];
3. **Scalene,** having three unequal sides [50];

With reference to their **angles:**—

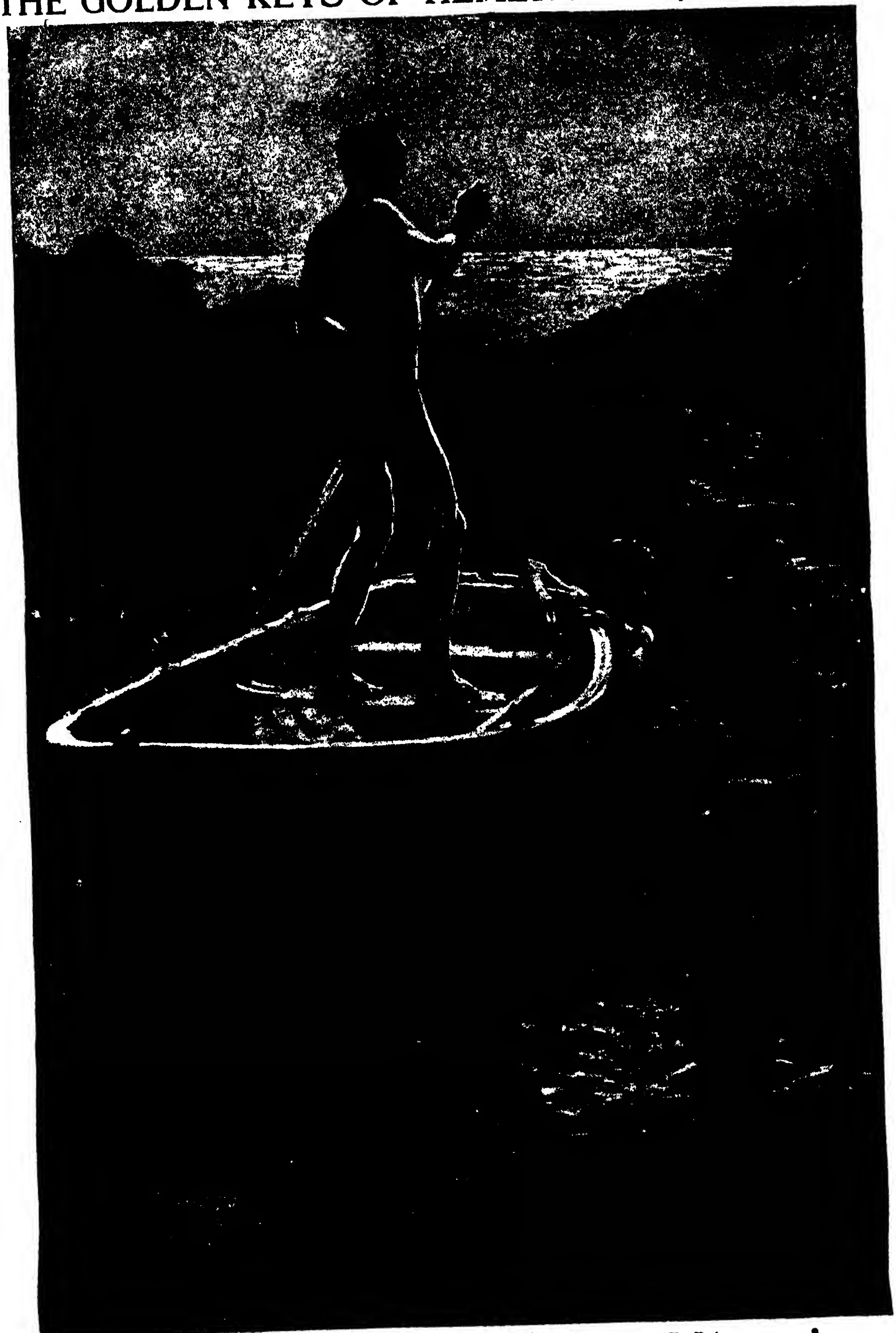
1. **Right-angled,** having one angle a right angle [51];
2. **Obtuse-angled,** having one angle obtuse [52];
3. **Acute-angled,** having all its angles acute [53].

UNDECAGON, an eleven-sided polygon.

The **VERTEX** of an angle is the point at which the two lines which form the angle meet.
Vertical angle. See **Triangle.**
A **Vertical line** is upright [40, B].



34–66. DEFINITIONS OF LINES, ANGLES, TRIANGLES, QUADRILATERALS, POLYGONS, AND CIRCLES.



FROM THE PICTURE OF "LOW TIDE," BY H. S. TUKE, R.A.

The Work Done by a Healthy Man. Health and Happiness: Preventive Medicine.

HEALTH AS ENERGY

Health is a word constantly on our lips, and yet when we try to define what we mean by the term we find it an extremely difficult task.

The root of the word is the same as the root of "holy" and "whole," and the conceptions of health, holiness, and wholeness have a vague element in common. All imply some sort of a perfection in structure and function. It is quite plain that a man who lacks moral sense is a spiritually unhealthy man, and that a man whose limb is paralysed is a physically unwhole man. Both have less than they ought to have.

We might define health as such a condition of mind and body as renders efficient all the functions of a man. But then we have to consider and define what are the functions of a man, and what we mean by the efficient performance of them. A few functions are common to all men. In all men the heart must beat, and must propel the blood ; in all men the breathing apparatus must work in a certain way ; in all men the nerves must convey sensory and motor impulses in a certain way ; but even taking these big functions common to every man, we are puzzled to find a definition of efficiency.

We can get over the difficulty only by taking a very broad view of the matter.

Man's body is a colony of co-operative cells ; man himself is a member of a colony of co-operative workers ; and any definition of health must take that fact into consideration. We might define health, then, in terms of energy, as power of work, and the best health of a man as that condition of the parts and functions of his body which make for the greatest total output of work by the whole conducive to the happiness of the individual and the community. That is the only definition, perhaps, that covers the whole ground.

A man in an epileptic fit may perform an enormous amount of muscular work, but it is not conducive to his happiness or the happiness of the community, and in the end it diminishes the total output of energy conducive to such ends. Therefore, on our definition, the man is unhealthy, or otherwise he does not enjoy the best of health. A man may have a very large, muscular heart working most efficiently, but if it be hypertrophied it will eventually diminish the total useful output of the energy his whole body possesses. His health, therefore, is not so good as it ought to be, or might have been, even though he may have found great pleasure, and the community may have found great pleasure, in the muscular performances that caused the hypertrophy.

Again, a man may have magnificent muscles, and use them for the happiness and good of the community, and yet if by doing so he have deplenished his mental energy—which, properly considered, is of much greater work-value, and much more conducive to the happiness of himself and the community—he cannot be considered in the best of health—in the best of health of which he was born capable.

Still, again, a man may have great potential muscular power and great potential brain power, and he may use his brains for the common weal, but fail to use his stock of muscular energy, so that his limbs are comparatively undeveloped ; and yet if during his lifetime he produce the greatest possible total output of energy for good he was capable of, he must be considered a healthy man.

It may be said that the conception of health is strained by such usage of the term, but it can be maintained that we merely elucidate its real meaning, and carry the most comprehensive definition of it to its logical conclusion. A man's energies are the real measure of his health, and his mental energy is capable of far more useful work than his physical energy, and must therefore be given more worth as a factor in health or wholeness. When James Watt invented the steam-engine, he produced more useful energy in a few years than an army of Sandows could produce by their muscles in a century.

Generation of useful energy must be the criterion of health, and in all estimates of useful energy mental energy must be given most value in terms of work and of

common weal. So much so, indeed, that the body must be considered mainly as a temple of the energy of the mind, and Keats's "Ode to the Nightingale" and Beethoven's "Moonlight Sonata" must be considered in any truly philosophic and scientific estimate of the health of Keats and Beethoven. The healthiest man is the man all of whose faculties, physical and mental, are working together to achieve the best work, judged in terms of quantity and *quality*.

The Healthy and Unhealthy Life. It is both unscientific and unphilosophic to talk of health as if it were something a man must either possess or lack. We all are whole, or healthy, or holy to some extent; we all do work of some value in terms of energy; and health and unhealth are matters of degree. An unhealthy man is just a man whose output of energy is deficient, and an unhealthy mode of life is a mode of life that diminishes total working power. Here, too, we find a basis for a useful distinction between disease and health. A man may have a decayed tooth or a troublesome corn, and yet may be a very healthy man. The disease may to some slight degree diminish his power of work in quantity or quality, but he is still producing practically all the energy of which he is capable, and, if that be a goodly amount, he must be considered a man in good health. The popular mind appreciates this distinction, for one often hears it said "So-and-so is suffering from typhoid or pneumonia, but is sure to get over it, since he is *such a healthy man.*" Health and disease are not the alternatives, but more health or less health, good health or bad health; and though disease sometimes impairs health and reduces energy, yet a diseased man may perhaps be more efficient than a man without disease.

We define, then, health as the sum total of useful energy, and ill health as a deficiency in the total amount of useful energy, or as such organic processes as reduce the sum total; while unhealthy functions, acts, and circumstances we define as functions, acts, and circumstances that reduce the total output of useful energy.

A certain complication is introduced by the time element. One man may walk six miles an hour; another man may walk three. Is the former man in better health than the latter? Both may be perfectly sound, and without an ache or pain, but, logically, the six miles an hour man must be considered healthier than the three miles an hour man, since, of course, work rapidly accomplished is of greater value, provided always it is not accomplished by mortgaging the future too heavily.

Gauge of Human Energy. The total quantity of work done in any time can be gauged by a man's output of carbon dioxide. All the work done by the human body—the lifting and falling of the ribs, the contractions of the heart, the impulses that run up and down the nerves—are all transformations of the energy of oxidation, and can easily be calculated in terms of heat by measuring the output of carbon dioxide, and by making allowance for the heat of the body. At rest we find that this output of carbonic acid is greater in men than in women, and in both sexes much greater during muscular exercise than during muscular rest, but any estimate of this kind is only an estimate of quantity, not of quality of energy; and nerve and mental energy judged by this criterion would have little value, since they are accompanied by very little oxidation. Nor can we tell by a calculation of this kind how much deleterious fatigue may follow the work. Only very roughly indeed can we estimate health by carbon dioxide, or by assimilation of food.

Health and Happiness Not Necessarily Akin. There is a great tendency to assume that health and happiness are correlated, and that, the more healthy a man is, the happier he will be. Even as disease means pain and discomfort, so health is supposed to mean ease and comfort. Health and disease, as we have just said, are not the antitheses of each other, but still there is some truth in this idea that health and happiness are akin. The energy that makes the heart beat steadily and strongly, that makes the footstep energetic and firm, that makes the breathing deep and powerful, that makes the vision centres and the hearing centres active and alive, that makes the thinking centres vigorous, is nearly always associated with a feeling of being well.

But, on the other hand, this same feeling may accompany work of body or mind that is wasteful, that is decreasing the sum total of potential energy, and that is doing no good either to the individual or to society. Thus, a man may increase his output of energy by alcohol, and be very happy while it lasts, and consumptives whose output of energy is increased by the fever of the disease are often the cheeriest and most optimistic of men. Energy can be considered health only if it be sustained; if it is like the widow's cruse; if income exceeds or equals, or almost equals, output. We say *almost* equals, for soon after maturity the income of the body, even under the most favourable circumstances, no longer equals the expenditure. The furnace of life gets choked with the ashes of its fires, the supply of fuel becomes less, and oxidation produces less energy and heat. This process of loss of power of work may be rapid or may be slow; but, again, the healthier a man, the more slowly will his potential of energy decrease, and for many decades he will seem to energise as vigorously as ever. And happily, as we have pointed out, mental energy, though more potent in its work, is less extravagant than physical energy; and great minds, like Kelvin, Darwin, Russel Wallace, sustain a large output of work till extreme old age.

When is a Man Old? One thing is quite certain, and that is that different men start life with different amounts of energy. We see that some men are old at forty, and others

young at sixty-five; we see that some men actually die of old age at fifty, and others live to be centenarians; we see, too, that this difference occurs apart from disease and apart from any difference in expenditure of energy. Scientific observers state that the aboriginal Australians are as old at forty-two as an average European at sixty-five. How is one to account for such differences? This is just one of the things no man can understand. All we know is just that natural longevity runs in families and races, and that the best way to live long, and to acquire all the energy that long life implies, is to choose long-lived parents.

But energy flows in different channels; and the centenarian who has merely hoed turnips or sold tobacco all his days may not in a life of a hundred years equal the output of work achieved by a great mental worker like Clerk-Maxwell in forty, nor can he be considered so truly healthy. The man who does not use his mind is at a great disadvantage in the race for health. However ruddy his cheek may be, and however big his muscle, his life is a very dull, inert, lethargic thing, his health is a very poor thing, compared with the life and health of the man whose energy works in the various channels of cerebral activity.

Despite such qualifications and exceptions, however, longevity must be considered as potentially, at least, a good thing, not only because it implies a large innate stock of energy, but because it enables a wise application of energy. There is a French saying: "*If only youth knew; if only age could.*" And it is possible for a hale and hearty old age both to know and to do.

The Waste of Energy and Health. Apart from actual longevity it is always a loss when a man's energies are squandered by disease or vice, or curtailed by accident or a hempen cord. It is health and energy that make a man; and the more years of useful energy he can obtain, the better for himself and society. And one of the saddest things in life is the way in which so much energy and happiness are lost by premature death, or by premature decay or preventible disease. Only one man in nine dies of old age—that is to say, lives till he has expended his innate energy. And the majority of those who die of old age have had much of their energy wasted by disease and unhealthy ways of living. Preventive medicine is a systematised effort to prevent wastage of health, and energy, and happiness. It takes measures to prevent preventible diseases, it takes measures to correct such material circumstances as may reduce the working capacity of men. The science and art it practises is usually called *Hygiene*, and the results it has achieved in the last century are most surprising.

Medicine, and surgery, and preventive medicine together are steadily increasing the span of human life, so that every child born nowadays has the expectation of several years' more life than he would have enjoyed had he been born in the beginning of last century. Even now the average span of life is only forty-three years; and many authorities consider that the natural span of life should be a hundred or a hundred and five, since the years of life should be five times as many as the years of growth, and the years of growth in man are twenty or twenty-one. But to this subject we will return when we come to deal with longevity.

The Signs of Physical and Mental Health. The outward signs of physical and mental health vary, and it requires an expert to interpret them. As a rule, a man who is capable of performing most *physical* work between birth and natural death is a man of medium height and build, with bright eyes, clear complexion, and firm muscles; but it is a commonplace that many men who look weakly, who are under-sized, with dull eyes and complexions, and small muscles, are yet capable of tremendous physical endurance. The mainspring seems to be chiefly in the constitution of the nervous system.

As a rule, a man capable of performing the greatest amounts of *mental* work between birth and a natural death are men of medium build and height, with bright eyes, clear complexions, small muscles, and good brows, but many brain workers lead lives that cause a deterioration of the physical side of health, so that many become heavy and sunken-eyed and obese; and many great cerebrums are concealed in very insignificant cases. One could hardly say that Mr G. K. Chesterton or Viscount Haldane, or Sir Oliver Lodge or Professor Stout, are of medium build. On the whole, the most constant sign of mental energy is a well-developed brow. Strangely enough, the front convolutions quite in front of the brain, and directly behind the frontal bone, have not yet been proved to be connected with the higher mental faculties. But no doubt they *are* connected with the higher faculties; and no one can regard a gathering of distinguished scientists without being struck by the extremely large proportion of well-developed brows.

Before considering the various measures which may be taken to improve and conserve health mentally and bodily, it will be well to take a very general survey of the nature of that vital energy of which we have said health consists.

Probably the greatest scientific achievement of last century was the discovery of the law of the conservation and transformation of energy. Robert Mayer discovered that no energy is ever lost, that it is merely changed into other forms of energy, and that each form has its precise equivalent in another form, and can, by suitable measures, be transformed into it. Thus, that form of energy called heat has its exact equivalent in a certain amount of energy which goes to move weights or do other mechanical work. The heat sufficient to heat a kilogramme of water 1° C. is exactly equivalent to the work necessary to raise 425 kilogrammes a metre high; and the amount of chemical energy involved in the combination and disruption processes in a chemical battery is exactly equivalent to the electricity produced, and to the heat and mechanical work the electricity can produce. No form of energy—light, heat, chemical affinity,

electricity—ever is born or ever disappears; the total form of energy in the universe, or at least in the world, is constant, but transformations of energy from one shape to another are constantly occurring.

The Sources of Human Energy. The energy and forces of the human body may seem very special, but they also must come under the same law. No energy is created in the body, but in the body perpetual transformations of force are occurring.

For a hundred years the heart may beat, and the brain may think, and the limbs may move. For a hundred years energy may be given off by the body in the form of heat. The body cannot create energy; then, where does the energy come from?

The energy, so far as the body is concerned, seems to begin by a molecular disturbance of the substance in the nerve fibres at the mucous and cutaneous surfaces of the body through the stimulation of environment, and this is propagated towards the central nervous system, and, by causing disturbances in the nerve centres there, gives rise to motion. The energy, then, is probably chemical energy transformed into heat and mechanical force. The chemical combination is evidently unstable, and the force of chemical affinity is readily changed into the force of heat and of mechanical work. But chemical affinity is a force that has its limits. One can get a certain amount of heat or work out of a pound of coal or a pint of petrol—a certain amount, and no more. The mechanical and thermal equivalent of all the tissues in the body is not very tremendous, and yet the mechanical work done by a man, and the heat generated by a man in the course of a lifetime, may be prodigious. The energy must be constantly brought to the man's body from some external source, to be transformed in the body into the so-called vital energies. From what source does it come?

The energy man uses to keep himself going is the energy of air and food. Deprive a man of food for a few days, or of air for a few minutes, and his energy soon goes.

Food and Energy. There does not seem much energy in a lump of sugar, or a potato, or a mutton chop, but if one burn them, or in other words add oxygen to them, we see that they produce a great deal of energy in the form of heat, and this is simply the force of chemical affinity transformed into heat. This, then, is where man gets his supply of energy from—from his food. He chews up his food, using for the purpose the energy of food previously assimilated; he breaks it up further by means of various ferments whose energy is also derived from food previously assimilated, and, building the fragments of the food into nerves and muscles and other tissues, he builds up explosive material which requires only the addition of oxygen to make it explode with the conversion of its chemical energy into heat and mechanical force.

To enter fully into the question here of the source of the energy in food would take too long, but we shall touch very briefly upon the question. The energy which is found in food in the potential form of chemical affinity must itself be the result of other energy transformed, for we know quite well that potatoes, and mutton chops, and bread, and butter were not always in existence, but have been themselves bound together. Whence comes the force that binds them together, and that is transformable by a little oxygen into the physical force of a Sandow, into the muscular agilities of a Pavlova, or the mental activity of a Kelvin?

Human Energy comes from the Sun. The force came from the sun, and chiefly from the red, and orange, and yellow waves of the sun. Tiny little waves they are, but they flash across space at the rate of about 190,000 miles a second. When they reach our retinas they are transformed into molecular disturbances that spread to the centres of sight in the brain, and appear in consciousness as visual sensations of red, and orange, and yellow, and hence we call them red, and yellow, and orange waves, though they certainly have no colour in themselves. When they beat upon our skin they are transformed into heat. When they reach the chlorophyll of a green leaf, they are transformed into a chemical force that tears the carbon and oxygen of the carbon dioxide of the air apart, and leaves the carbon and the oxygen dowered with the latent energy of chemical affinity. The oxygen thus torn free rushes about seeking whom it may devour. The carbon joins with water in the green leaf and becomes starch, a substance also containing energy in the form of chemical affinity or synthetic force. By its chemical energy, in turn, nitrogen obtained from the soil by the plant is bound up with its molecules to form nitrogenous products also containing energy. Animals eat the starch and nitrogenous matter, and build them into their tissues. Finally, the red blood corpuscles, each with a cargo of oxygen, flow down the arteries and capillaries of the tissue, and the oxygen burns up (oxidises) the food-formed compounds in the tissues, and the energy of the sun is transformed again into waves of heat and also into mechanical work.

The energy, then, that keeps man going is the energy of the sun added to his tissues in the form of food containing that energy in the shape of chemical affinity. A green leaf, a sunbeam, a speck of starch, and, lo! the energy of a man!

It is difficult, perhaps, to believe that sunbeams contain so much mechanical energy, but it has been calculated that on an average sunny day of eight hours' sunshine the sunlight falling on each square yard is equal to one horse-power.

To have health and energy, then, we must lay in a store of the sun's energy in the form of food, and we must obtain plenty of oxygen in order to liberate it. The basis of health is air and food, including water, and all studies of hygiene must start with a study of these two great and essential factors. In the next chapter, accordingly, we will begin the study of the laws of health, and discuss in detail the relationship of food and air to the functions of the human body.

RONALD MACFIE

Symptoms and Method of Treatment of the Chief Diseases of Horses, Cattle, Sheep, and Pigs. A Medicine Chest.

DISEASES OF LIVE-STOCK

DISEASES OF HORSES

The temperature of the body frequently proves a guide in sickness. The stockowner should therefore obtain a clinical thermometer and learn how to use it. The temperature of the horse is from 100° to 101° F., a rise to 103° denoting a feverish condition, and from 105° to 106° a high fever. The bulb of the thermometer is very carefully introduced into the rectum, and kept there for three to four minutes in order to obtain an accurate reading. The pulse, which is taken under the side of the jaw, beats from 36 to 45 times per minute in health, but the horse must be perfectly quiet. A beat of over 60 denotes fever. The pulse is rapid and small in such complaints as inflammation of the bowels, and weak in influenza; but inasmuch as its volume, rhythm, and character are all important, professional help should be obtained in cases of grave suspicion. Under normal conditions, the horse, when standing quiet, breathes 12 times in a minute.

The stockowner should note that there are certain contagious diseases—to the names of which [N] is prefixed—which are scheduled, and which must be notified, even where the complaint is only suspected. All being dangerous to man, this notification, accompanied by absolute isolation, is all the more important.

Colic and Gripes. These common complaints are frequently caused by improper feeding or sudden change of food, by impaction, by the taking of too much green food, or by drinking a quantity of cold water when overheated. The animal perspires freely, and rolls on the ground in pain, which may be spasmodic. An injection of warm water often affords relief, or a dose of from 5 to 10 drams of aloes where spasm exists. If there is flatulence, linseed oil or ammonia is useful, together with massage. It is important to ascertain that the case is not one of inflammation, in which the pain is continuous. Gripes are often removed by a draught composed of chlorodyne, hyposulphite of soda, and bicarbonate of potash, the dose being arranged by an experienced chemist, who should be acquainted with the animal's age and condition.

Enteritis. This very dangerous disease, usually known as inflammation of the bowels, from which animals seldom recover, somewhat resembles colic, but the temperature is high, the body cold, the pulse fine and hard, and the belly tender. Hot fomentations are useful, but there is practically no remedy, although the best skill should always be employed.

Gastritis. This disease, inflammation of the stomach, closely resembles that just referred to, and is almost equally dangerous. Amateur physicking should be avoided.

Diarrhœa (Scour). This is more common in young than in older animals, and may be attributed to chill, sudden change of food, improper food, acidity, or worms. The cause should first be ascertained, and the remedy applied in accordance with it. Foals with their dams may receive a dose of castor oil and laudanum, while acidity in the milk of the dam may be neutralised by the aid of carbonate of soda. Mixtures of opium powder, catechu, and chalk, or of catechu and chlorodyne, may be administered, the dose being arranged by a druggist in accordance with the animal's age and condition.

Glanders and Farcy [N]. This contagious disease—for glanders and farcy are practically one—must, even on suspicion, be notified to the police, the horse being isolated. It is contagious to man, and is the result of the work of an organism known as *Bacillus malleus.* There is a sticky discharge from the nostrils, usually, however, from one nostril. When the disease is recognised or proved by the injection of the material used for the purpose, and known as mallein, the horse is destroyed. In bad cases there is high fever. Glanders and farcy take different forms, the latter affecting the limbs and skin, one disease running into the other.

Catarrh. This somewhat common complaint is not of a serious character, although it should be promptly handled. It is due to the sudden changes of the weather, coupled with bad or irregular feeding, and indigestion, and may cause loss of condition and weight. A horse with catarrh should be rested in an airy yet warm and dry stable, and fed on simple food, such as mashes of bran, crushed oats, linseed tea, and cooked roots. Little drink should be given. Terebine and spirits of camphor are useful.

Pink Eye, or Distemper. This is an infectious disease attended with great loss of strength and condition, and accompanied with a thin discharge from the nostrils, cough and fever. The temperature may rise to 104° or 105° F. A redness of the membrane of the eyelid is usual. There is thirst, constipation, and scanty urine, with a weak pulse. The animal should be stabled, as in the case of catarrh, isolated, well nursed and fed, receiving gruel, eggs, and milk, if there is great loss of strength, mashes, linseed tea, and steamed crushed oats. A little spirit may be good to sustain the strength. The temperature should be taken, and, if the attack is severe, a veterinarian should be employed, as there are occasionally serious complications, involving pleurisy, bronchitis, or the liver.

Pleurisy and Pneumonia. Pleurisy is inflammation of the membrane covering the lungs. There is cough, a thin and wiry pulse, with high temperature. The animal should be clothed and kept warm, and mustard applied to the affected part.

Although pneumonia is probably due to the presence and action of a specific germ, it may be indirectly owing to exposure, overheating, and chill, or even a damp stall. The pulse is tiny and very rapid, and the breathing quick. A case should be treated with great promptitude by a professional.

Strangles. This chiefly attacks young horses. Its most important symptom is an abscess under the jaw, which is usually blistered or fomented until it breaks, or is ready for the lance. In either case it should be kept clean with antiseptics.

Fistula. This disease appears on the withers, and should be attacked immediately it is noticed, inasmuch as if neglected the bony structure beneath

may be implicated and recovery become impossible. The aid of a veterinary surgeon is essential, that the part may be opened and cleansed. The affected horse should not be worked, but allowed freedom for sufficient exercise and pure air. The feeding should be sound but not high, the efforts of the owner being directed to maintenance of good bodily condition, that the animal may throw off the abnormal formation, and build up new tissue.

Cracked Heel, Curb, and Founder. Cracked heel is usually accompanied by lameness, and may be caused by a wet stall or constantly wet feet. Washing the feet should be avoided, the dirt being allowed to dry and then removed with a brush. White vitriol ointment may be employed, as for thrush and sore shoulders.

Curb is a swelling which appears a little below the hock, and is better recognised in profile. The part may be blistered or fired.

Founder, or inflammation of the feet, frequently follows bad feeding, cold or wet. The feet become heated, and the horse is in pain, and prefers to rest. He loses condition, and exhibits great thirst, the pulse being meanwhile strong. The shoes should be removed, and cold bran poultices applied to the feet. The bed of the stall should be covered thickly with short straw or peat moss, and very little exercise given, and that on soft soil. A few draughts or drenches should be obtained to help the animal through, a little green food being given when recovery begins.

Capped Hocks. This is practically a swelling of a tendon, which is followed by a condition resembling a cap over the point of the hock. It may result from a bruise. The seat of the disease may be in or beneath the tendon. The horse should rest, and the affected part be regularly dressed with a lotion obtained from a druggist skilled in these matters, or from a veterinarian.

Broken Knees. Broken knee is usually the result of a fall. A mere bruise or graze, if kept clean, rapidly heals, but where the joint is opened there is a discharge of fluid (synovial), usually known as joint oil. As this is serious, attention must be given at once, and even then prolonged rest and nursing will be necessary for recovery. Care must be taken to remove any grit or dirt, and the wound should be dressed with a special lotion and then bandaged. Both cleaning and dressing should be frequent, the sponge being soaked in water which has been purified with an antiseptic. An oil of cloves dressing on cotton-wool will be found useful.

Grease. This term is applied to a greasy condition of the skin of one or more limbs, and is sometimes accompanied by a discharge. The affected parts may be powdered with boracic acid and alum, and kept clean and carefully bandaged. The animal should be fed well, green food being supplied; a ball from the veterinarian will help to bring back condition.

Mud Fever. This is really an irritation caused by the presence of dirt; an eruption also appears, usually on the legs, with loss of condition. The horse may be fed on bran mashes, crushed scalded oats, with a little green food and an odd mangel or carrot or two, or with a little first-class hay; an ounce of linseed oil may be given each night and a few powders obtained from the veterinarian.

Navicular. This is a disease of the navicular bone and its surroundings, usually in the fore feet. The horse goes shaky or limp, and although he may do a little work he becomes practically unsaleable. Help can be given, but no cure effected, by a veterinary operation, after which a short-toed shoe with a leather sole may be provided for the affected foot.

Quittor. This involves a swollen and heated coronet with running sores, often caused by the presence of matter arising from a wound in the sole; the matter is discharged from the suppurating sores instead of below. Whether the wound is caused by a nail or otherwise, the place should be cleaned with an antiseptic dressing and encouraged to discharge below by poulticing. In the presence of quittor, however, the sores must be opened, cleaned, and induced to heal by the promotion of a healthy condition of the affected parts. Rest should be given, and the work performed by a veterinarian.

Ringbone and Ringworm. Ringbone usually in the hind legs, may be seen when really large, or detected by the fingers of an expert on or near the pastern joint. It may be caused by a blow followed by inflammation and lameness. Rest and firing by a veterinarian may possibly have good results.

Ringworm is caused by a parasite, the irritation being followed by loss of hair. The patches should be kept clean, and dressed with tincture of iodine or an ointment.

Sandcrack. In this case the horny structure of the hoof cracks, and may cause lameness; the extension of the crack must be prevented, and a healthy condition promoted by light exercise, cleanliness of the part, and the drawing of the divided portions together. The horse must rest if it is in pain.

Sidebone. This is a hardening of the flexible cartilage behind the cannon bone, usually on the fore legs. It diminishes the value of a horse, although he may do good work for years. Rest may be necessary, and sometimes firing, but turning out in suitable weather for some weeks may have excellent results.

Spavin. Serious as this complaint is in the horse used for fast work, farm and cart horses suffering from it are commonly employed and often work as well as when sound. Spavin is the result of inflammation which attacks the bone of the hock, and which is followed by enlargement and lameness. If the enlargement is not noticeable, it may yet be discovered by the touch of a skilled hand. The horse should be rested and professionally treated, and the wisest plan is to turn the animal out to grass if weather permits.

Splint. Splint attacks horses ridden and driven rather than cart or farm horses. It is really a bony deposit on the cannon bone, usually on one of the fore legs, which causes lameness. Both heat and pain are present. The former may be reduced by cold sponging, and the latter by resting. A blister may be found useful, but one should be guided by a professional man.

Thoroughpin. This trouble is a fluid distension or swelling, which is movable, and which appears at the back of the hock. It is sometimes painted with iodine, and sometimes punctured, but needs professional treatment.

DISEASES OF CATTLE

Anthrax, or Splenic Fever [N]. This very dangerous disease, known under many names, usually attacks young stock; it is due to the presence of a bacillus, and is extremely fatal. The attack is

sudden, the limbs swell, stiffness follows, with loss of appetite, extreme weakness, and a weak and rapid pulse. In severe cases death may follow in a few hours. A veterinarian should be called in at once, and no time lost in efforts to sustain strength and to ameliorate the symptoms. The best plan, however, is to act on the principle of prevention, keeping the stock in good condition, never turning them out into fields where anthrax has occurred, and, on farms where there has been loss from the disease, to insert a seton in the dewlap. In case of attack the animal should be isolated, its bed and manure burnt, and its stall purified, while after death its body should be buried in lime, or still better, burnt, if this is possible.

Catarrh. This is recognised by a running at the eyes and nose, which may follow chill and exposure. It should be checked before going too far, as it may be succeeded by complications of a most serious character. Protection and good feeding are essential. The animal may receive a dose of Epsom salts, in accordance with its age, well fortified with ginger. In a severe case the feeding should consists of good gruel, warm bran mashes, scalded oats, and good hay-chaff, and, if obtainable, some green food—grass, clover, or vetches—given in small quantities at a time. The system needs stimulating and well feeding, while a dry stall, ventilation, and a little exercise should be provided.

Consumption, or Tuberculosis [N]. This is perhaps the most destructive among all diseases of cattle. It has been stated on authority that 40 per cent. of the cattle in the country are affected. If it is suspected, the tuberculin test may be applied by a veterinarian, the rise in temperature, if definite, deciding the question.

No tuberculous beast should be sold or allowed to remain near healthy stock, infection being extremely dangerous. Milk should not be sold from a tuberculous beast, nor calves and swine fed on the milk, unless it has been boiled.

Red Water. This serious complaint is usually recognised by the dark or red colour of the urine, and diarrhœa, which is usually followed by constipation. Unless in very severe cases, a pound of Epsom salts may be given as a purge, followed by daily doses of oil and turpentine. The disease is accompanied by great weakness, so that good nursing and rich feeding are essential. The animal should receive milk, gruel, linseed tea, and, if necessary, spirits, but in all cases it is desirable to obtain professional assistance. The cause of the disease is not fully known, but it is more common on moorland soils than elsewhere.

Influenza. The symptoms resemble intensified catarrh, with fever and prostration. The disease is contagious. If there is constipation, as is most likely, a pint of linseed oil may be given, a little more, if necessary, followed by enemas if the trouble is continued. The animal should be isolated, and advice obtained in all cases. The feeding may consist of bran mashes, gruel, and a little green food from time to time. Water in which linseed has been boiled may be given as a drink. The animal should be kept warm in a well-ventilated stall, and good nursing and rest provided.

Pneumonia. This is recognised by a hard cough, cold ears and feet, hot, rapid breathing, chill, weakness, and refusal to eat. The exciting cause is usually exposure and chill. The patient should be well wrapped up in a dry air-box, and fed on milk, mashes, linseed tea, and a little green food. It is always well to obtain an accurate diagnosis, advice, and medicine from an expert.

Pleuro-pneumonia [N]. This is a contagious disease, which must be reported when recognised. It is frequently fatal, running its course with rapidity. There is thirst, cough, refusal to feed, a hot, dry muzzle, foul-smelling breath, and foul, dry manure, with, in bad cases, wasting, and running mucus from the mouth. The disease is imported. In all suspected cases there should be isolation, disinfection, professional advice, and slaughter on recognition.

Foot and Mouth Disease [N]. This is a contagious and disgusting disease, which must be notified to the police. There is shivering, salivation, weakness, rapid pulse, with inflammation, eruption on the mouth, tongue, oftentimes on the feet, and sometimes on the udder. An aperient should be given, to consist of a pint of linseed oil or ¾ lb. of Epsom salts, the affected places being dressed with a sulphate of zinc lotion. Salicylic acid in ¼-oz. doses, or sulphite of sodium in 3-drachm doses in water, may be given twice daily. If the feet are attacked, boracic acid may be dusted over them.

There should be isolation and complete disinfection. Patients may be supplied with linseed water as drink, linseed tea, milk, mashes, gruel, cut grass, and any food likely to tempt the failing appetite. The milk of affected cows should not be used for healthy stock.

Slinking, or Casting Calf. Abortion is caused by accident, exposure, or contagion, the calf being usually cast in the fifth month. In any case the cow should be isolated, thoroughly disinfected, and all matter connected with it buried with lime, or burnt. A cow which has once been affected should not be used for breeding again until nine months have elapsed, or she may be fattened and sold. There is always danger in buying in-calf cows in fairs and markets; hence the importance of some days of isolation before mixing with the herd. After a case of abortion every animal in the herd should be disinfected by syringing with a solution composed of 20 pints of distilled water, 3 oz. of glycerine and alcohol (specific gravity 36), and 2½ drachms of bichloride of mercury (poison). Bulls should be disinfected before service by syringing.

Milk Fever, or "Drop." This very dangerous complaint often attacks cows which are in high condition and of particular strains. The animal falls soon after calving, displaying weakness, a dry, hot muzzle, and perhaps relapses into a state of coma. The actual cause is unknown; prevention is the wisest course. Fleshy or suspected cows should be turned out on scanty pastures after drying off, or, if stall-fed, kept on light rations, of which bran mashes form part, linseed water being occasionally used to keep the bowels in order. A pint of salts given twice with intervals shortly before calving is a practice many follow with success. Where the appearance of the cow raises suspicion that she may fall, 10 to 12 drops of tincture of aconite may be given, and continued every six hours or so, if there is no change. Where a case occurs, the animal should be well wrapped up to maintain warmth, the bowels being kept open with linseed oil, salts, or a gruel enema.

Garget. This is a troublesome complaint attended with great risk and loss in value in the cow. The udder is attacked by inflammation, and its internal structure involved, so that the power of yielding milk may be lost. It is usually owing to chill, injury, or bad management. The udder

becomes hard, but may be massaged, and the calf used to empty it from time to time. When garget appears, the udder may be poulticed with linseed meal, and medicine obtained from the veterinarian. If an ulcer forms, it should be kept clean with an antiseptic, such as carbolic acid, 1 part to 25 parts of water. Simple *hard udder*, which often occurs after calving, may be reduced by giving ¾ lb. of salts and an ounce of ground ginger in gruel, followed by frequent rubbing, and by allowing the calf to suck oftener.

Hoven and Impaction. Hoven usually occurs from overeating young, fresh green food in spring, especially where cows break bounds and enter a field of vetches, clover, or some other green crop when the dew is upon it. The animal is blown with gas, parts of the abdomen, when tapped, resounding like a drum. In bad cases the distension presses on the heart, the circulation is impeded, and death may occur by suffocation.

The commonest simple remedy is ½ lb. of hyposulphate of soda, given in a pint of water, this being repeated in a short time, if necessary. If it is perceived that a cow is in danger, the paunch should be pierced by a trocar and canula, which should be kept on every farm, or, failing this, with a penknife, behind the short ribs on the left side. The trocar is removed, and the canula, through which the gas quickly passes, remains in the wound, which should be kept clean, and which with care will quickly heal. After relief the animal must be nursed, first getting an aperient—1 lb. of Epsom salts, with some ground ginger, or a pint of linseed oil—to clear the bowels. Food should be given in small quantities until danger has passed; it should include gruel, bran mashes, and linseed water.

Impaction is also the result of gorging abundant dry or green food. There is less gas in this case, but action should be taken with linseed oil to purge the system. In bad cases advice must be obtained.

Colic. This trouble is often caused by overfeeding or bad feeding, followed by pain in the bowels, the generation of gas, and swelling. The first remedy is 1 lb. of salts, with 1½ oz. of ginger, ½ oz. of aloes being sometimes added. If necessary, a stimulant must be supplied, and in all cases help obtained. There may be gentle massage with dry mustard. The feeding to follow relief should be chiefly composed of bran mashes. Colic may be caused by chill, or drinking too much very cold water. Where there is little gas evolved, but more pain, a pint of linseed oil may be given, followed by a soothing drink, which should include opium, obtained from a veterinary surgeon.

Enteritis. This disease is accompanied by pain, perspiration, and rapid pulse. It is caused by exposure and chill, and the consumption of quantities of cold water when the animal is heated. Ether and opium are usually given, but, again, the owner should leave himself in the hands of a skilled adviser.

Diarrhœa (Scour). If the dung is largely mixed with mucus, great weakness soon follows an attack, but simple looseness, although it should not be ignored, may mean nothing. Bad cases occur from sudden changes of food or of pasture, from the consumption of bad food or water, and from chill. A pint of linseed oil with an ounce of tincture of opium may be given to clear the bowels, after which a binding draught may be administered, if necessary, this consisting of powdered chalk, catechu, and opium, the doses being arranged by a good druggist.

the dung is mixed with blood; there is great weakness, and inflammation of the organs of digestion. In such there must be prompt action, good nursing, and the best advice. Diarrhœa in calves is caused by acidity, chill, and careless feeding. In ordinary cases 1½ to 2½ oz. of castor oil may be given in accordance with the age and size of the animal, followed by periodical doses of a cordial containing powdered chalk, ginger, opium, and catechu. It is prepared by any good druggist. Many cases of diarrhœa are infectious, hence the importance of supreme cleanliness and isolation.

White Skit, or Scour. This is common among calves taking milk. In ordinary cases the oil and cordial may be given as above, but where the disease is the result of a bacillus, Nocard's system must be adopted. The animal shivers, there is rapid emaciation, and death. The discharge is very thin, and a yellowish-grey. Practically no treatment succeeds in effecting a cure. The one thing is to prevent its occurrence. The bacillus enters the system through the navel cord; hence, when the cow is about to calve, she should be kept in a disinfected box on clean straw. The cord of the calf after birth should be tied with thread 1½ to 2 in. below the navel, and cut an inch below the tie. The cord should then be dressed with a solution composed of 1 gram of iodine crystals, 2 drachms of iodide of potash, with 500 cubic centimetres of water ($1\frac{1}{10}$ pints), and subsequently coated with a solution of 1 gram of iodine crystals and 500 cubic centimetres of alcohol. This must be allowed to dry thoroughly, when a layer of 1 per cent. iodine collodion should be painted or coated over it, and well dried before the calf is released. Cows about to calf should be disinfected with a 2 per cent. solution of creolin in water. The hands of the operator and the knife and thread employed should be sterilised or disinfected.

Broken Horns. In bad cases the stump may be removed; in others it may be smeared with the best Archangel tar, bound with tow, and subsequently with a clean cotton bandage.

Cowpox. Pustules appear upon the teats, being usually communicated by the hands of milkers; hence the importance of cleanliness. The affected teats may be bathed with a mixture of ½ oz. of chloride of lime in two quarts of water.

Poisons. The most common vegetable poisons are yew and rhododendron; but whether these have been eaten, or whether the animal has in some way consumed mineral poisons, the services of an expert are essential.

The pulse of a beast is taken at the jaw, and is 45 beats per minute, while the temperature, which is taken in the rectum, is 101° F.

DISEASES OF SHEEP

The remarks we have made on anthrax and foot and mouth disease under the head of Cattle apply also to sheep. Both diseases are notifiable.

Catarrh. This is indicated by a running at the eyes and nostrils, sometimes with the addition of a cough, loss of condition, and refusal to feed. The animal should be isolated, nursed, kept warm, and fed with gruel, to which a drachm of nitre may be added from time to time.

Pneumonia. An attack of this disease is accompanied by fever, loss of condition, thirst, laborious breathing, and refusal to feed. It is caused by exposure and chill, and is dangerous. The

strength should be maintained by the aid of spirits, two tablespoonfuls being given in linseed tea, milk, or gruel, with a little ginger added. Expert advice is essential in dealing with pneumonia.

Braxy. Braxy is a highly fatal disease, which it is almost useless to treat. The head hangs, the back is rigid, and there is grinding of the teeth. The direct cause is believed to be found in bad feeding, especially on decomposing grass. A palliative is found in a supply of salt to the flock, and good, sound pastures. The diseased sheep should be at once isolated, and a purgative in gruel may be tried, or a veterinarian called in, but in all cases slaughter is the most economical course to adopt.

Dysentery. This is recognised by abnormal, fetid droppings, mixed with mucus and blood, with fever, weakness, and refusal to feed. It may be caused by a chill. The sheep should be isolated, well fed on flour gruel, and in mild cases treated with powdered chalk and opium, the quantities to be in accordance with age, or the cordial for scour in calves may be administered.

Hoove. This results from fermentation of food and the production of gas, as in cattle. When a flock is placed on green food or roots, the allowance should be limited until they have become accustomed to the change. A purge of 3 oz. of Epsom salts with a little ginger is advisable, followed by oatmeal gruel, about 4 oz. at a time. If the symptoms do not abate, the trocar and canula may be used.

Parturient Fever. This disease is the result of blood-poisoning, often following delivery by the shepherd with hands which have not been disinfected. It is accompanied by fever, the discharge of a dark fluid, pain and diarrhœa, and is highly dangerous. When assisting a ewe, the shepherd should take the greatest care to purify his hands with diluted carbolic acid, 1 part to 50 of pure water, and, if necessary—indeed, it almost follows that it is necessary—the parts may be syringed with a mixture of 1 part of carbolic acid to 10 parts of glycerine. If the affected animal needs a stimulant, two or three tablespoonfuls of whisky or brandy at a time may be given in flour gruel, adding an ounce of tincture of opium if there is diarrhœa.

The pulse of the sheep, which is taken at the heart, beats 75 times per minute, while the temperature of the body is 101° F. When medicine is administered, it should be from a small bottle with a long, narrow neck, the fluid being slowly and gently passed down the right side of the mouth, and kept clear of the tongue.

DISEASES OF PIGS

The diseases of pigs which are notifiable to the police are swine fever, foot and mouth disease, and anthrax. The two latter have already been referred to in connection with cattle, and need no further description.

Swine Fever [N]. This very destructive and contagious dsease should be handled with promptitude and energy. Where any doubt occurs in diagnosis, the veterinary inspector or surgeon should be immediately called in. Affected swine show fever, great thirst, refusal to feed, and a skin patched with purple, especially on the belly. A case should be immediately isolated on presenting such an appearance, and on being declared as swine fever each animal affected should be slaughtered, and others which have been in contact with them isolated and treated under the advice of the Government inspector. Every place occupied by diseased pigs should be thoroughly disinfected.

Inflammation of the Lungs. This is due to exposure and chill, and is accompanied by a dry cough, abnormal breathing, and shivering. In cases where the disease is not severe, and where the condition hardly warrants slaughter, the patient may be kept in a dry, warm sty, and rapidly fed for the butcher. It may possibly be found that the liberal use of new milk with good meal will be followed by a rapid increase in weight and the prevention of any serious loss. An affected pig needs exceptionally good feeding and nursing, with dry warmth and plenty of air. A light blister, made by mixing mustard and turpentine, well rubbed over the affected part, is sometimes followed by good results, but this should be accompanied by medicine obtained from the veterinary surgeon.

Measles. This troublesome complaint is accompanied by fever, pustules under the tongue, and red blotches on the skin. The patient should be kept in a warm, dry, well-ventilated sty, supplied with good food, such as milk given slightly warm, together with an ounce of sulphur twice daily.

Rheumatism. This chiefly affects young pigs, which apparently become cramped, especially in the hind limbs. The complaint is caused by lying upon damp beds, hot manure-heaps, or even cold stone, concrete, or brick floors with insufficient straw. Wooden benches well covered with dry wheat-straw should be provided, so that the animals can make themselves warm and comfortable. A mixture of turpentine and mustard may be rubbed well into the affected limbs.

Sore Throat. Sore throat is a serious complaint, often resulting in death. There is swelling on the throat or neck and tongue, while the membrane of the mouth becomes abnormally dark in colour. The pig rapidly loses condition and strength, and, unless the disease is arrested, death speedily follows. The throat may be fomented, Epsom salts administered at the outset, and the advice of a veterinarian obtained.

A Useful Medicine Chest. The following materials should be kept in store by every stock-feeder. They chiefly consist of simple remedies or appliances which any intelligent man may employ upon recognising the complaint which they are intended to relieve. We think, however, that in all serious cases the preparation and administration of medicine should be left entirely to those who have been properly trained for the purpose. In deciding upon the employment of a veterinary surgeon, it may be well to arrange to pay for his services by an annual sum or by definite fees.

LIST OF MEDICINES

Condy's Fluid	Carbolic acid (poison)
Tincture of ammonia	Nitre
Powdered aloes	Spirits of camphor
Epsom salts	Linseed oil
Castor oil	Olive oil
Mustard	Powdered ginger
Sulphur	Prepared chalk
Powdered catechu	Spirits of tar
Archangel tar	Sheep dip
Foot-rot ointment	Calf cordial

INSTRUMENTS AND MATERIALS

Trocar and canula	Clamps for castration
Clinical thermometer	Twitches for horses
Knee-caps and bandages	Searing iron

Diseases of stock due to animal parasites are dealt with in the course on NATURAL HISTORY.

JAMES LONG

The Electricity of the Atom. An Imaginary Atom. Experimental Atoms. Valency and Chemical Union Explained by the Electron Theory.

THE MODERN THEORY OF MATTER

THE root question of chemistry is the nature of matter, and we have already seen that, while matter has the habit of existing in the form of atoms, these are elementary only in the sense of the older chemistry. Plainly, we must proceed to dissect them. Now, atoms are not mere aggregates or heaps or accumulations of simpler components—one atom, let us say, consisting of half a dozen, and another of ten. An atom, like a man or a society, is not an *aggregate*, but an *integrate*—that is to say, is not a *heap*, but an *organism*. A heap of stones is an aggregate; the cathedral which may be composed of such a heap of stones is an integrate; and it is not without reference to this analogy that we have had occasion to liken an atom to St. Paul's Cathedral.

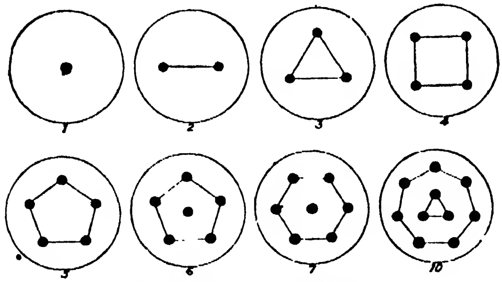
The Anatomy of the Atom. In discussing, then, the anatomy of the atom (the reader will observe the interesting contradiction in terms—the cutting up of the uncuttable)—in discussing the anatomy of the atom, we have two distinct problems. The first is to ascertain the nature of the units which compose it, their different kinds if they be of different kinds, and their characters; the second is to ascertain their relations to one another—with this noteworthy complication: that these relations are not permanent and changeless, such as the relations of the stones in a building, but are constantly undergoing rearrangement, which strongly suggests the evolution of thoughts and feelings in the mind of man, or the evolution and molecular change that are to be found in a living cell.

On account of reasons which will probably make themselves evident, we may begin with the second problem, towards which we are more directly led by our previous study of the older chemistry. For the moment we shall ignore its more difficult part—the question of the changes of relation that constitute the evolution of an atom. Admitting that such changes occur, we may ignore them, and confine ourselves at present to a study of the relations between the parts of an atom as they are believed to persist for long periods—perhaps thousands or millions of years in the case of the lighter and more stable atoms. It would obviously be premature at this stage of our exposition to tackle directly such a complicated question as that of the birth of the helium atom from the atom of radium. But the reader is already aware that we have identified bodies which we may call electrons or corpuscles, and of which atoms are composed—in part at any rate. In the case of radium, we knew them at first as the *Beta* rays, and their distinctive characteristic is that they carry a charge of negative electricity.

The Electricity of the Atom. For the present we need no more facts save to remember that if these negatively charged corpuscles are to live together so as to constitute an atom, there must be some bond of union between them. "Like electricities repel"; one negative corpuscle will not be reconciled with another unless there be "positive electricity," so-called, which will master them both. We may thus assume, according to the teaching of several students, the first of whom in our time was Lord Kelvin, while the chief worker is Sir Joseph Thomson, that an atom is an area where there is positive electricity of such an amount as will balance—as will exactly balance, if the atom be stable—the sum of the negative electricity of all its constituent corpuscles added together. We might assume that the atom was a flat object, that all its electrons lay in the same plane, but it is more satisfactory, and doubtless much more nearly true, to assume that the atom is spherical, and has, in short, a tri-dimensional character. For the present we will make this assumption, but the reader must on no account allow himself to be persuaded that atoms are asserted to be really spherical. The sphere, however, is the simplest figure that we can choose if we are to abandon any attempt to represent the atom as a flat object, and the sphere is, beyond a doubt, much nearer the truth.

An Imaginary Atom. Now, Sir Joseph Thomson's inquiry was this: assuming that the atom is a sphere of positive electrification, in which lie a number of negatively electrified bodies, how would they tend to arrange themselves, and what would be the consequences of their arrangement? In order to simplify our problem we must assume—and never forget that we have only assumed it, not proved it—that the electrons, or negatively electrified corpuscles, are at rest. We have, of course, every ground to believe that they are by no means at rest, but we must attack the simpler question first. Again, it is believed that in the case of the simplest known atom—that of hydrogen—the number of electrons, or negatively electrified corpuscles, must be from 700 to 1000, but, plainly, we cannot begin with such figures, and must consider what would happen in the simplest conceivable case. The simplest of all is that, of course, in which there is only one negative electron, such as exactly to balance the positive electrification of the atom. In such a case, the negative electron would lie at the centre of the sphere. If there were two corpuscles, they would be balanced with themselves, and with the positive electricity—that is to say, the atom could exist as a stable object, assuming that no outside force interfered with it—on condition that they

were placed upon a diameter of the sphere at points exactly midway between the centre and the circumference. If there were three corpuscles, they would have an equally simple arrangement, forming an equilateral triangle, symmetrically arranged about the centre of the sphere. If there were four corpuscles, they would form a square; five would form a pentagon. And at this point we begin to reach a marked difference. We might expect that, if the number of corpuscles were increased, they would behave just as they do when the number is so few—that is to say, they would arrange themselves in a continuous figure, just as if they lay on the surface of a smaller sphere placed within the sphere that constituted the boundary of the atom. But they would not and cannot.



ELECTRONS IN THE ATOM

Not so Simple as it Looks. Such an arrangement would appear satisfactory, since it might be supposed that the whole structure would be balanced by the positive electricity and the negative electricity, thus having what looks like a symmetrical arrangement. Supposing this were so, the difference between a heavy and a light atom would depend simply upon the number of the corpuscles that constituted it, and the difference in the relations between the corpuscles would simply amount to this: that in the lighter atom they were less crowded than in the heavier. There might thus be a perfectly regular arrangement; there might just as well be an atom containing 937 corpuscles as one containing 938. One would not be more stable than the other, and the properties of the two would differ in the infinitesimal degree which the difference in their structure would require.

But if we look at the list of the elements arranged, let us say, in order of atomic weight, we find no such simple sequences. There is not a uniform measure of increase in weight as we ascend the list, nor is there a uniform change in the properties of the elements represented. The pre-eminent feature of such a table, as we have again and again insisted, is that it is *periodic.* Groups of characters come and go, and come again. There is a more or less regular recurrence of them. That is the whole meaning of the term "periodic law."

The Survival of Atoms. Now, Sir J. J. Thomson has shown that directly the number of corpuscles increases beyond five in the model atom we have imagined, a new kind of arrangement is met, and the result of his mathematical inquiries, together with certain experimental facts, and together with the known facts of the periodic law, leads us to the conclusion that systems such as we have imagined are stable only under certain conditions. For instance, if there were 938 corpuscles in such a sphere, it might be stable; but if by chance it lost one, the 937 could not arrange themselves in any stable fashion. It might be necessary for 21, or any other number of additional corpuscles, to be lost before a stable structure could be possible. Is it not more than probable that the gap between, let us say, uranium and radium, or lead and silver, is capable of some such explanation as this?

And here, again, we may discern a new meaning in the assertion which we made in a previous chapter as to the possibility that Empedocles was right, and that the law of natural selection, or the survival of the fittest, is true of atoms as well as of living things.

Brief Life of the Atom. We remarked that the reason why there is so very little radium in the world is that its atom is unstable; it can survive for only a brief time, so that many specimens of it cannot accumulate. It was further asserted that we must now regard the few score different kinds of atoms with which we are acquainted as the relatively stable survivors from an infinite number of conceivable atoms, most, or indeed all, of which may have momentarily come into existence again and again, but have been unable to survive. It is believed that the number of electrons in an atom of mercury is about 200,000, and those in an atom of radium about 250,000 (perhaps more nearly 225,000 electrons in the atom).

Why, then, should there not be at least 225,000 or 250,000 elements, if it be not that the laws of atomic structure permit less than a hundred to survive?

Sir J. J. Thomson has shown that, instead of one ring or sphere of corpuscles, two are necessary directly we go beyond the number of five [see diagram]. Of these, one consists of fewer corpuscles than the other and is nearer the centre; throw in a few more, so to speak, and three groups are required, later four, and so on. It has been said that we conceive of the atom as having three dimensions, but it is possible to make most interesting experiments of the highest illustrative importance and having strict accordance with Sir Joseph Thomson's calculations from purely abstract considerations, if we are content for the moment to conceive of the atom as having two dimensions only—that is, as being flat.

Experimental "Atoms." The experiment was devised by Professor Mayer. First, a surface of still water represents the plane of the flat atom. Each negative corpuscle is represented by a little magnetised needle, which is made to float by being thrust through a piece of cork. The needles are all arranged so that the negative poles are uppermost and the positive poles below. The negative poles behave to one another as the corpuscles of an

atom must behave to one another, tending to repel one another with a force varying according to the law which is now so familiar to us—the law of inverse squares. Now, some arrangement has to be provided to represent the positive electricity which holds the atom together, and this is easily done by a positive magnetic pole which is hung over the water.

Supposing we start with one needle; it is immediately fixed under the magnet. Throw in another. The first moves from its original position, and the two assume the positions we have already defined; and so on through the triangle, the square, and the pentagon, until, when a sixth needle is thrown in, we find not a hexagon but a pentagon, with one needle in the middle of it. Later on, two go to the middle, then three, forming a triangle; then there is a square, a pentagon, *and so on and so on* [see diagram].

We must closely recognise the significance of this. Here is the periodicity which the other arrangement—now proved to be impossible—did not display, the periodicity which the periodic law demands. For observe what happens, supposing we strip off the outer ring and leave an inner triangle [see 10 in illustration on page 2419].

Plainly, we have an atom such as one we have already seen. Plainly, also, the fact of the triangle will tend to make the larger atom resemble, in some degree at any rate, the smaller. Perhaps the one stands for chlorine and the other for bromine. And another fact needs almost equal emphasis. It is the sudden transformations of the entire grouping which may be caused by the insertion of one needle more, while if yet another be added there may be little modification. It just takes its place in the outer ring. That is true, for instance, if the numbers be 16, 17, and 18; but if one more needle be thrown in, the whole structure is changed, and, as it happens, the change is still more marked when the twentieth is thrown in. Supposing we multiply all these figures by a few hundreds, we can now readily understand how it is that numbers of corpuscles intermediate between the figures so obtained could not form a stable atom at all. They might make a momentary attempt to form an atomic organism amongst themselves, but it would immediately evolve into a more stable form.

Rotational Grouping of Electrons. The complication introduced by the fact that the electrons must certainly be conceived as in motion is not so serious as would appear. We can imagine these various rings in a state of rotation around the centre of the sphere, without the grouping of the corpuscles being altered in any way.

The complexity introduced by the fact that Mayer's needles are in a plane, while the corpuscles of the atom must have a tri-dimensional arrangement, is much more serious, but it is by no means insuperable. Already Sir J. J. Thomson has succeeded in his initial attack upon it, and, so far as the plane arrangement is concerned, or the arrangement in rings rather than shells, he has shown how such corpuscles must be arranged up to numbers well on the way to a hundred.

Application of the Theory to Valency. Let us now see what facts this new theory of the structure of matter enables us to understand, premising most clearly that we are by no means attacking the ultimate question yet, but have merely advanced our problem from the stage in which the properties of the atom seemed to be entirely mysterious to a further stage in which they seem to be more or less intelligible—both stages being no further than atomic, however. We are very far indeed yet from considering the further question which must face us afterwards. But, taking the subject at this stage, let us see which of the properties of matter we can explain, confining ourselves for the purposes of the present course to those properties which may be called more distinctly *chemical.*

In the first place, let us take valency, the curious property of atoms in virtue of which they seem to have a varying number of "arms," while the newly discovered group of inert atmospheric gases have no "arms" at all. When we come to study the behaviour of Mayer's needles, or of the negative electrons which we have conceived, according as 13, 14, 20, etc., of them are organised within one area of positive electrification, we find an intelligible explanation for, at any rate, the main facts of valency, and are not without prospect of explaining all the rest.

We find that when there are, let us say, 60 corpuscles in the organism of the atom —the reader, of course, understands that the figure is quoted merely "for purposes of illustration"—the addition of one more corpuscle does not fundamentally alter the structure of the atom. In another case it is similarly found that the subtraction of one corpuscle does not fundamentally alter the structure of the atom; or the atom may tolerate the loss or gain of two corpuscles or three, but no more.

Atoms such as the first we have supposed will be one-handed, the others will be two-handed, three-handed, and so on respectively. Thus, we may reasonably suppose valency in any case to be determined by the number of electrons which the atom in question can gain or lose without having its whole constitution altered—without, for instance, having to arrange its electrons into three groups instead of two, or five instead of six.

The No-Handed Elements. The reader may ask what chemical differences correspond to the difference we have suggested by using the alternative "gain or lose," and we shall now see that the alternative corresponds quite satisfactorily to observed facts. But let us spare a word for the no-handed elements. Now, it is the most remarkable fact that this zero group of elements fits as satisfactorily into Thomson's theory as we have already seen it to fit into the periodic law of Mendeleef. On the supposition already stated, the peculiarity of the particular numbers of electrons that compose the atoms of the members of this group should

be that they cannot tolerate the loss or the gain of *even one electron* without losing their stability. Such a structure plainly will be without any combining power at all. Now, it is found that the arrangement of 59 electrons and also that of 67 is in this case, and it is surely very much more than a coincidence that seven atoms are possible between these two, and that seven atoms do in fact occur—lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine—between helium and neon, as also indeed between neon and argon. Thus, the theory provides a satisfactory explanation for valency and for absence of valency alike.

The Explanation of Chemical Union. This magnificent theory will also lead us to understand the fundamental facts of chemical union. Plainly, it would not be of very profound value if it failed to explain the most characteristic and abundant of all the facts of chemistry. For long years men have spoken of chemical forces and chemical affinity and chemical energy. The philosophic mind has always expected that some day these powers would be resolved and recognised as essentially one with the other manifestations of energy in the universe. The physicists long ago outstripped the chemists in a similar respect. They showed the identity of heat and energy of motion [see PHYSICS]. They showed the correspondence between heat and work, heat and electricity, and so on; and they framed, over half a century ago, the great generalisation of the conservation, the convertibility, and the ultimate identity of all the forms of energy. Sooner or later the chemists had to fall into line with this doctrine—as, indeed, they did not hesitate to admit.

The Electrical Nature of Chemical Forces. Of recent years, evidence for the ultimately electrical nature of chemical forces has accumulated, and Professor Thomson now seems to have solved the problem altogether. The chemical elements are divided or classified according to their electrical properties, some being more or less markedly electro-positive, while others are more or less markedly electro-negative. If we look at a list of the elements we find that, let us say, No. 1 is what is called electro-positive, and so on increasingly till No. 8, which is still more so, whereas No. 9 is very electro-negative, and so on. There is not a continuously steady rise and fall in this electrical property, but sudden interruptions, and then continuous rise or fall for a time. Thomson's theory of atomic architecture completely explains this fact.

An atom with a certain number of electrons has, let us say, 15 in the outer ring and 10 in the inner. Now, according to mathematical theory, 10 is the smallest number for the inner ring that is compatible with the presence of 15 in the outer ring. Such an atom has, so to speak, no rope to spare. It is electrically unstable or electro-positive; add another electron, and it becomes very unstable or electro-positive; and then, at a certain point a totally new arrangement is reached, and the atom becomes very stable or electro-negative again. Well, let us suppose that sodium and chlorine atoms are placed in one another's company. The sodium atoms are electro-positive, and are readily capable of losing one electron apiece, being therefore also one-handed. The stability of the chlorine atoms, again, is compatible with the acquirement of one electron apiece. They are thus electro-negative and also one-handed. Obviously, the circumstances are fit for combination between these atoms and the compound sodium chloride will result, owing to an electrical attraction between the positive atom of the metal and the negative atom of the halogen. The electron which the one atom loses is conveniently accommodated in the other atom.

Explanations of Periodic Law. We have already insisted upon the importance of the fact that the arrangement of Mayer's needles—as experimentally observed, and as demonstrated about ten years ago at the Royal Institution by Sir J. J. Thomson before the most illustrious audience which the present writer has ever seen there—that this arrangement has a definite law of periodic recurrence as the number of needles is increased. Purely abstract mathematical considerations have also demonstrated the necessity for this periodicity. At last we see why, on reading the table of the periodic law, we come at recurring intervals to elements that resemble one another. Whereas we find that No. 1 and No. 2 are dissimilar, No. 1 resembles Nos. 9, 16, and 23, let us say; while No. 2 resembles Nos. 11, 18, and 25. Thus we have groups such as lithium, sodium, and potassium; phosphorus, arsenic, and antimony; the group of the halogens, and so forth. While these resemble one another chemically when subjected to the ordinary tests, the physician can add the corroborative evidence that their actions on the human body display similar resemblances. The theory of Thomson fits in to a nicety with all these facts.

What One Electron May Do. Our imaginary atom with 20 electrons may have them arranged in an outer circle of 12, an inner of seven, and one central one, which has got as near as it can to the positive magnet as illustrated in Mayer's experiment. If another needle or electron be inserted, the whole arrangement may be completely altered. You get an atom of a totally different kind; which is to say that you get an element having totally different properties, as different, let us say, as the properties of sodium and magnesium—which follows it in the table of the periodic law. But when a certain number more be added, what we find is a reproduction of the original arrangement with the addition of an outer circle, representing the new electrons added. Plainly, the first arrangement suggests such an atom as sodium, the last arrangement such an atom as that of potassium, and the theory explains the similarity between the two; while the intermediate arrangement or arrangements represent the atoms of magnesium, aluminium, silicon, phosphorus, sulphur, chlorine; the unlikeness between sodium and potassium on the one hand, and all these other elements on the other hand, being similarly made intelligible.

Value of the Theory. Indeed, this great theory co-ordinates and illuminates whole series of facts hitherto awaiting explanation. It is justly comparable to discoveries like those of gravitation, Mendel's law, the association of ideas, or the circulation of the blood. The discovery of the periodic law constituted an epoch in chemistry. It consisted in the observation, grouping, and correlation of a very large number of individual facts. It is really worth while to point out the remarkable correspondence between the work of Mendeleef in this respect and the great labours of Kepler. The astronomer spent years in observing the planets and finally deduced from them his three laws of planetary motion. They constituted an epoch in astronomy, but obviously neither the periodic law nor Kepler's laws constitute the final stage of the inquiry. In each case we must ask a further question: What is the explanation of the laws already ascertained? Why do the planets move in this fashion? Why do the elements display this periodicity? The Kepler and the Mendeleef are alike essential, but their work is completed and their labours crowned when a Newton arises to elucidate the greater law of gravitation, of which the laws of planetary motion are merely consequences, and a Thomson arises to elucidate the fundamental fact of atomic architecture, of which the periodic law is similarly only a consequence. Indeed, we are able to say that if matter be really made of electrons the atoms of the elements are inevitably bound to display that periodicity of properties which Mendeleef demonstrated but could not explain, just as Kepler demonstrated but could not explain the movements of the planets.

Further Proof. Every kind of confirmation that can possibly be suggested is being found to come to the service of what its author calls the corpuscular theory of matter. We have already mentioned facts of valency and of absence of any valency; the facts of chemical union; the facts of the periodic law; the facts of the grouping of the elements. To these we may add the facts of the triads of elements which were mentioned in a previous chapter. It was pointed out that in the case of chlorine, bromine, and iodine, for instance, or calcium, strontium, and barium, the atomic weight of the middle element stands almost exactly midway between the atomic weight of the first and third elements. It is an easy matter to study the groupings of small numbers of corpuscles as, for instance, 61, 41, and 25, and show that if these numbers be taken to represent atoms, the atomic weight of the middle atom is about half-way between the atomic weight of the first and third atoms. The three atoms closely resemble one another. The fact is explained when we look at the groupings. Twenty-five corpuscles form three rings, containing 13, 9 and 3; these three rings are found to recur when we take 41 corpuscles; there is merely a fourth ring of 16 added outside them. Again, they recur when we take 61 corpuscles, having this time not merely the fourth ring of 16, but a fifth ring of 20.

A completely different method of inquiry affords yet new confirmation to Thomson's theory. It is found that when the light emitted by any element in a glowing state is analysed by means of the spectroscope, constituting the process called Spectrum Analysis [see PHYSICS], definite and distinctive characters can be recognised as belonging to each element, such characters ultimately depending, of course, as we now see, on the structure of their atoms. Now if we take the spectra of a group of elements we find that they are related to one another in structure, and Sir J. J. Thomson has shown, by mathematical reasoning, that groups of electrons related to one another in the fashion indicated in the previous paragraph would necessarily produce related spectra of the kind actually observed.

Groups and Series. Reference has already been made to the fact, which we may well emphasise, that the electrical characters of the elements afford further confirmation of the theory. When elements are arranged in groups, as in the table of the periodic law, we may read the columns downwards, in which case, for instance, we get such a sequence as helium, neon, argon, krypton, xenon; or may read across, in which case we get such a sequence as that recently quoted, consisting of the seven elements that lie between helium and neon—*viz.*, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, these elements belonging respectively to groups one to seven. Such a sequence as this last constitutes what, in order to emphasise it, we call a *series* of elements as distinguished from a group. Now, a group consists of members which closely resemble one another, but we must recognise that there is also a relationship, though of a quite different kind, between the members of a series. This relationship is most clearly expressed in the case of the electrical properties of the elements already referred to, and corresponds in the most amazing way with the relationship which ought to exist if Thomson's corpuscular theory be correct.

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The Last Stage. Now we must ask the reader to recall certain statements which we made in introducing this part of our subject. The whole significance of Thomson's theory has not yet been stated. We have yet to apply it to the existence of unstable atoms and to see whether it explains their behaviour as well as it does that of the stable atoms with which we are now familiar. Furthermore, as has already been insisted, we have by no means pushed to the last stage our inquiry in what we call the root question of chemistry. It is all very well to speak of a sphere of positive electrification, for instance, but whence does it come? Of what, or in what does it consist? Similarly, with the negative electrons. When we discussed radium we spoke of the shooting out of some of these from the atom of radium. But if these things are the ultimate constituents of matter we must follow them and see what becomes of them.

C. W. SALEEBY

The Coming of the Slavs, Bulgars, Magyars, and Wallachs, and their Struggle for a Foothold in Europe.

THE RISE OF THE BALKAN STATES

The origin of the states of South-eastern Europe must be sought in the history of the East Roman Empire. We have long outlived the curious prejudice which affected to regard the Byzantine Empire as fit only to be relegated to the limbo of things best forgotten. It is doubtful, even now, if we realise adequately the excellence of the immense and imposing edifice which Justinian founded and Leo the Isaurian completed. Yet, if stability and vitality, if power of cohesion and recuperative virtue, be the true tests of political efficiency, then the East Roman Empire must be pronounced one of the most marvellous political organisms which ever existed.

The same ethnographical revolution which bridged over the gap between ancient and mediæval history in the west operated in the east likewise, but with this great difference: while the old order of things in the west vanished at the first touch of the new barbarian hordes, in Eastern Europe the empire gradually transformed and assimilated the new elements without suffering irreparable damage to itself for many centuries. The unique situation of the imperial city; the more pliable and adaptable genius of the Greeks (for from Justinian onwards the Hellenic element predominates); the intellectual superiority of the Constantinopolitan government, which invented and triumphantly applied the science of diplomacy when brute force was, everywhere else, the *ultima ratio*—these were the most salient advantages which enabled the rulers of New Rome not only to weather the earlier and more terrible tempests of the transmigration period, but also to provide against similar perils in the future.

The first barbarians with whom the reconstituted empire had to do were the Slavs. As early as 449 one of the numerous branches of this great family, possibly the Serbs, established themselves along the northern banks of the Danube, extending as far westwards as Dalmatia. An ancient and respectable tradition claims both Justinian ("Upravda") and Belisarius ("Velichar") as members of this race. Somewhat later, about the end of the sixth century, the Bulgarians, a Finno-Ugrian race, migrated from the steppes between the Don and the Dnieper, settled in Mœsia, and, by the ninth century, were completely Slavicised in their new surroundings. Both races became the nominal subjects of the empire, which aimed at making them serve the double purpose of buffer provinces towards the north and recruiting grounds for the imperial generals, while at the same time preserving a local autonomy.

But the Bulgarians, who remained heathens for two centuries after their inclusion within the confines of the empire, were too martial a race to submit to any yoke for long. The empire was continually at war with them; more than once they besieged Constantinople itself, and their onslaughts were the more perilous as they coincided with the interminable attacks of the Arabs from the south. During a considerable portion of this period the Bulgarian hosts must have included the Servians also as subject auxiliaries. Bulgaria and Servia were converted to Christianity about the same time (about 864-867) by the famous Orthodox missionaries Cyril and Methodius and their followers.

The process was accelerated by political considerations, and had important political consequences. Two new kingdoms, for whose alliance east and west competed, arose within the Balkan peninsula. The first independent Servian kingdom—founded by Peter in 872—was of comparatively brief duration, but the Bulgarian kingdom of Boris and Simeon lasted for two hundred years and overshadowed the eastern empire itself. At the period of its greatest expansion the Bulgarian realm stretched from the Danube and Drave to the Rhodope and Pindus ranges, embracing the whole valley of the Danube, nearly the whole of Thrace, and large parts of Thessaly, Macedonia, and Epirus.

In 866 the eastern empire first came into contact with another Slavonic race, the Russians, who, a few years previously, had

established themselves under their Norse leaders at Kiev, on the Dnieper, immediately abutting on the vast south-eastern steppes.

It was an ideal resting-place and starting-point for predatory barbarians with a taste for adventure. In 907, Oleg, prince of Kiev, imposed a heavy tribute upon Constantinople, but his successor, Igor, in 945, made a perpetual peace with the Greeks, and Christianity began to permeate "the land of the Russ."

The Christianity of the Russians. In 955 the Russian princess Olga was christened at Constantinople, though it was not till 990 that Vladimir the Great—who, two years previously, had been baptised at Cherson, in the Crimea, on which occasion he married the Greek princess Arna—forcibly converted the Kievlyans to the new faith with the assistance of Orthodox missionaries. Henceforth the relations between the two states were almost uniformly friendly. Svyatislav, prince of Kiev (945-972), even aided the Greeks against the Bulgarians; but during the latter part of the tenth and the beginning of the eleventh centuries the intercourse between Constantinople and Kiev was interrupted by the interminable Bulgarian wars which engrossed the attention of the emperors of the Macedonian dynasty. During the interval the young Russian Church, under Yaroslav the Great (1019–1054), became virtually autocephalous.

The Weakening of the Greek Church Faith. Hitherto the most potent weapon of the imperial city on the Bosphorus, a weapon far more effectual than diplomacy, regular armies, or Greek fire, because it had a moral aim and a supernatural sanction, was the Orthodox religion. But at the beginning of the eighth century the very foundations of the Orthodox religion were undermined by the rationalistic movement known as iconoclasm. There can be no doubt that a closer acquaintance with Mohammedanism as a religion promoted scepticism as to the central verities of Christianity among the more speculative Byzantines, especially in the eastern provinces of the empire.

The War Against Images and Ritual. To such theorists a deism like the religion of Islam would seem clearer, purer, and more natural than the highly developed, dogmatic system of Christianity, with its intricate, interpretative ritual. The emperors of the Isaurian and Armenian dynasties, who reigned from 717 to 867, themselves more Oriental than Hellenic, and certainly statesmen rather than theologians, imagined that the readiest way to defend orthodoxy against the onslaught of a deistic philosophy was to abolish or at least to curtail as much as possible everything symbolical in religion, as being parasitical, or at best superfluous, and therefore more liable to attack from outsiders. Hence their open, persistent war against the icons, or images. It was the same principle, in a less extreme form, as that which moves the more destructive section of the higher critics of our own day to eliminate the miraculous element from Scripture.

Slav Symbolism Conquers Ideality. But strong men though the iconoclastic emperors were, they were not strong enough to reform orthodoxy. The sole results of all their efforts in this direction was the division of the empire for a century and a half into two fiercely antagonistic camps, whose hostility seriously weakened both the Church and the commonwealth. Historically, the ultimate victory of the opposing, or icondulist, party meant the triumph of the Hellenic and Slavonic over the Oriental elements in the empire.

The two following centuries (867–1018) were a period of recovery and re-expansion under the princes of the great Macedonian dynasty. Its salient features are the systematic conversion of the southern Slavs, and their subsequent life and death struggle with the empire for the hegemony of south-eastern Europe. All the previous wars had been, more or less, plundering raids; these later wars were for political ascendancy. Finally, at a terrible cost, the empire prevailed, and Basil II. (976–1025) once more extended its limits to the Danube.

The Coming of the Magyars. Within the same period occurred an event of capital importance to the Slavonic race generally, which, roughly speaking, at that time occupied the whole of Central Europe from the Baltic to the Danube. That event was the intrusion of the Magyars, or Hungarians. The Magyars, presumably an Ugro-Finnic race, though the real origin of this interesting people is still a riddle, are first heard of on the right bank of the Don, the Lebedia or Livadia of Greek chronicles. Expelled thence by the more numerous Pechenegs, they took refuge in "Etelcum," as the contemporary Greeks called the districts roughly corresponding to Podolia and Moldavia, and were immediately, in the year 893 or 894, enlisted in the service of the Byzantine emperor, Leo VI., against the Bulgarians.

Occupation of the Hungarian Plain. In 985 their chieftain, Arpad, led them through the Vereczke pass into what is now the "Alföld," or great Hungarian plain, but which then formed the eastern portion of the vast, shadowy empire of Moravia, extending from Prague to the Drave and the Vistula. By 905 the Magyars had occupied the whole of this plain, separating permanently the northern and western Slavs from their southern and eastern brethren, and thus changing the face of Central Europe.

The Borderland of East and West. For nearly a century after the "honfoglalás," or "occupation," as Hungarian historians call it, the Magyars continued to be pagan and predatory, ravaging east and west impartially. Tamed at last by the disasters of Augsburg, in 955, and Adrianople, in 970, they set about putting their house in order. For some time it was doubtful whether they would accept Christianity from Pope or Patriarch. Proximity favoured the Eastern Church, and the first Hungarian prelate, Hierothus, consecrated "Bishop of Turkia," came from Constantinople.

IN THE GREAT DAYS OF HUNGARY—LADISLAUS V. VOWING TO PROTECT THE HUNYADIS

On the death of John Hunyadi, his family were intrigued against by the Hungarian nobles. The young king vowed to protect them, but broke his vow, and executed the elder son. Matthias, the younger, escaped, and eventually became king.

The Hungarians Join the Western Church. But as the Byzantine empire grew stronger and stronger under the Macedonian dynasty, fear of a neighbour so formidable and so near moved the Hungarian duke Geza to solicit missionaries from Piligrim, bishop of Passau. The question to which branch of the Church the Magyars were to belong was settled, once for all, when Saint Stephen accepted the kingly crown from the hands of the Pope, Sylvester II., in 1001. Christianity was not, however, definitely established in Hungary till the beginning of the twelfth century, and even then a large pagan population, constantly reinforced from the outer barbarians—notably the Cumanians, or Huns, who were planted in large colonies beyond the Theiss—had to be tolerated by their Christian neighbours.

beginning of the struggle, centuries long, between Hungary and Venice for the command of the Adriatic, which ultimately resulted in the triumph of the latter.

The Formation of "Buffer" States. The most dangerous period for Hungary was when the Comnenian dynasty restored for the last time the supremacy of the eastern empire. During the glorious reign of Manuel (1143–1180), himself a semi-Magyar—he was the grandson of St. Ladislaus—this danger became acute. Manuel treated the Hungarian throne as if it were a family possession, but he was too much occupied elsewhere to attempt to conquer the country; and on the collapse of his dynasty, shortly after his death, Hungary once more became a conquering power. This (1173–1196) is the period of the acquisition of those "banates," or protective

THE VICTORIOUS TURKS ON THE BATTLEFIELD OF KOSSOVO, WHERE THEY ROUTED JOHN HUNYADI AND THE SERVIAN ARMY IN THE YEAR 1448

The Struggle for the Command of the Adriatic. Fortunately, the immediate successors of St. Stephen were men of valour and genius, quite equal to the double task, difficult as it was, of preserving domestic order and, at the same time, of asserting the independence of the young central kingdom alike against the eastern and the western empires, both of which repeatedly endeavoured to reduce it to the condition of a vassal state. One of these early princes, St. Ladislaus (1077–1095), conquered and Christianised Croatia. His successor, Coloman, went still further, and extended the boundaries of Hungary to the sea, successfully contesting the possession of Dalmatia and its islands with the rising young Venetian republic. This was the

marches, Rama, or North Bosnia, Macso, or North Servia, and Szöreny, or West Wallachia, which so long protected Hungary from the incursions of her southern neighbours.

A Relapse to Barbarism, and Rescue from it. The thirteenth century, however, was a period of dire calamity and complete disintegration. The degeneracy of the Arpad dynasty, the consequent domination of a lawless and conscienceless oligarchy, the Tartar cataclysm (1240–1243), the haphazard re-peopling of the ruined kingdom with semi-pagan elements like the Cumanians, resulting in a general lapse into savagery affecting their dynasty itself—all these visitations and the cumulative effect demonstrated that Hungary must be regenerated from

A CONQUEROR OF RUSSIA A THOUSAND YEARS AGO

RURIK, THE SCANDINAVIAN HERO, WHO SUBJUGATED RUSSIA IN 862, AND FROM WHOM SPRANG A LINE OF PRINCES, THE HOUSE OF THE RURIKOVITCH, WHO WERE RULERS IN RUSSIA FOR SEVERAL CENTURIES

without if she were to remain a member of the Christian commonwealth. The Holy See, therefore, wisely intervened; the last Arpad was hunted down, and the iron discipline of feudalism, administered by the great princes of the Neapolitan branch of the House of Anjou (1308–1382), raised the fallen kingdom once more from her ashes to an unprecedented degree of power.

The Dominance of the Slavs. Meanwhile, the Balkan peninsula had become predominantly Slavonic. The Greek empire disappeared from Europe. Its supplanter, the feudal empire of Romania, withering rapidly in uncongenial soil, had, within a few years of its foundation, virtually shrunk within the walls of Constantinople. It was an easy task for Michael Paleologus, in 1261, with the aid of the Genoese and the Venetians, to cleanse the orthodox capital from the Latin débris. But the new empire was but a shadow of the old one. Its restoration was mainly a successful commercial speculation on the part of the Italian maritime cities. The Greeks were from the outset too heavily burdened by their obligations to their allies to profit by their delusive good fortune. They could pay their debts only by reducing their armaments, and collapse was the inevitable, if long-postponed, result. Anyhow, from the beginning of the thirteenth to the middle of the fourteenth centuries Serbs and Bulgars triumphed over Greeks and Latins alike, and divided the inheritance of Constantinople between them.

Balkan Dissensions Through Race and Religion. Unfortunately for themselves, and for Europe, the great Nemanyidæ and Asyenidæ dynastics, which represented Servia and Bulgaria respectively, were constantly at war with their neighbours and with each other, and the intermixture of religious with political questions —such, for example, as the rivalry of the two young autocephalous churches and the proselytising efforts of the popes, to whom more than one "rex Slavorum" owed his kingly crown—prevented anything like stability. Another more insidious but none the less powerful solvent was the Bogomil heresy. This unnatural and antisocial revival of manichæism—which established itself in Bulgaria between 927 and 968, and by the end of the fourteenth century had permeated all the Slavonic races of the Balkan peninsula—though most virulent and indomitable in Bosnia, struck at the roots of domestic, social, and political life, and was one of the most powerful contributory sources of the comparatively easy triumphs of the Turks over the outwardly imposing but inwardly rotten Slavonic kingdoms.

A MEETING BETWEEN MATTHIAS HUNYADI OF HUNGARY AND GEORGE PODIEBRAD OF BOHEMIA IN 1468

The Irresistible Regulars of the Turks. The Turks, on the other hand, when they first appeared above the European horizon—capturing Gallipoli in 1356—were uniquely equipped for a career of conquest. Already they alone of all nations possessed, in the "Jenicheri" (the Janissaries), a regular standing army recruited from the flower of the conquered populations, and bound together by the indissoluble ties of a discipline which was a tenet of their religion. How could the self-willed, undisciplined hosts of South-eastern Europe stand before veterans whose first and last duty was absolute obedience to their leaders? Five years after the transference of their capital from Broussa to Adrianople, the forces of the united Slavonic kingdoms were annihilated on the field of Kossovo in 1389. The gallant attempt of the feudal chivalry of

Hungary and Western Europe to stem their progress failed miserably on the field of Nicopolis in 1396. By the end of the century their empire stretched from the Danube to Thessaly.

The Turks Tighten Their Hold on the Balkans. The destruction of Sultan Bajazet I. by Tamerlane the Tartar, or more correctly Tatar, at Angora, in 1402, presented Christendom with the only real opportunity it has ever had for expelling the Turks from Europe at next to no cost. The opportunity was neglected, the young Osmanli empire was allowed a quarter of a century to recover from its wounds, and by that time the fate of the southern Slavonic lands was sealed. For the next 500 years they were simply Turkish sandjaks, or military districts, with no history of their own.

The Hungarians as Defenders of Europe. Constantinople owed its brief respite to the energetic intervention of the Hungarians, who were routed, indeed, at Varna in 1444, and again at Kossovo in 1448, owing to the undisciplined impetuosity of the feudal chivalry, but, under Janos Hunyadi and his son Matthias, held the balance equal during the critical last half of the fifteenth century. The victories of these extraordinary men, which so astounded their contemporaries, were due principally to their consummate generalship. They were the first to demonstrate that a skilfully handled, regular army of Europeans was a match for almost any number of Janissaries and spahis, however brave, unless the odds were absolutely overwhelming, as they proved to be at the battle of Mohacs in 1526. The victorious Hunyadis were materially assisted by a new nationality, the Wallachs—from which they themselves were descended—who founded semi-independent principalities in Moldavia (1354–1359) and in Wallachia (1338–1369). It is evident, from the earliest-known coins of the Wallachs, that their rulers were Slavs of the Ruthenian, or Little Russian, stock, and originally vassals of the Hungarian Crown.

The official language of the Hospodars of Moldavia and Wallachia was Ruthenian for centuries to come, though the people over which they ruled seemed to have been the descendants of Trajan's Roman colonies, and spoke a language in some respects even closer to Latin than either Italian or Spanish.

Wallachs Become Tributaries to the Turks. The independence of the Hospodars was necessarily short-lived. Their principalities traversed the line of least resistance to the Turkish advance, and, at the best of times, they were dependent either upon Hungary or Poland, according to circumstances and political exigencies. Wallachia paid tribute to the Porte as early as 1396; Moldavia not till 1513. But their comparative distance from Stamboul enabled them to maintain some pretence of autonomy at the worst periods of their chequered history, and the Turks themselves regarded the Danubian principalities as something higher than the down-trodden provinces of Servia, Bulgaria, Bosnia, and Greece. In the figurative language of the Divan, they were "the two wings" by means of which the Padishah could take further flights northwards.

R. NISBET BAIN

GRAND DUKE VLADIMIR MONOMACH, WHO RULED IN KIEV EARLY IN THE TWELFTH CENTURY

Considerations in the Inception of a Railway. Potential Earning Powers and Costs of Construction and Maintenance.

RAILWAY CONSTRUCTION

The objects for which railways have sometimes been built are very diverse, and include military and political objects. Many railways in Russia and other parts of Europe and in India have been constructed with a single eye to the movement of troops in time of war. Other railways, of which the Canadian Pacific Railway is an example, have been initiated, if not maintained, to effect or consolidate the political union of the countries or provinces through which they run. The Uganda Railway has been built to introduce civilisation into that part of Africa, and in numerous instances, particularly in British India, there are railways the construction of which would have been indefinitely postponed, if not utterly abandoned, had it not been for the necessity of providing work for a famine-stricken population.

All these examples of railway building, though their existence should be borne in mind, are in their nature exceptional. The main object of railway building is to supply a commercial need in return for a commercial recompense. The great majority of railways are built with this object alone, and there are no railways, even among those referred to, which have not been built with a careful regard to this end.

What a Railway is. A railway may be regarded from more than one point of view. Considered merely as a physical entity, it may be defined as a roadway adapted for the exclusive use of vehicles provided with flanged wheels. This definition would also include street railways, or what we now call *tramways*. A railway as understood in this country is confined to ways with rails raised above the level of the ground. A railway may also be regarded as an economic organism; and this is an aspect that must never be lost to view, since upon the success or failure of a railway as an economic organism its expansion or decadence as a physical entity depends. Economically considered, a railway is simply one of the numerous organisations necessarily evolved by all civilised communities for the purpose of carrying its members and their goods.

If successful, it will develop and expand as the numbers and wealth of the community grow, and its success will depend upon the efficiency with which its functions are performed in competition with other railway organisations and with different forms of locomotion.

Competition. When once it has been ascertained that a district affords sufficient traffic to justify the construction of a railway, there is no other consideration of such far-reaching importance as that of the competition which may immediately or ultimately arise.

The profits to be derived from a commercial undertaking can under ordinary circumstances never exceed greatly that of the usual return from other enterprises of like standing, since if the profits are much higher, competitors will be attracted to its particular sphere of activity, and thus tend to reduce the profit to a more usual level.

Exceptions occur when the enterprise is in some way protected from competition, whether by law or from physical causes.

When the line of an existing railway occupies the only feasible route between two or more centres of population it is protected by physical causes from the competition of other railways, and, to a great extent, from the competition of other forms of land locomotion. In default of an only feasible route, if a railway occupy the best possible route which the topography of the country affords, a great measure of protection will be secured. By this it will be seen how important it is, in fixing the line of a new railway, to discover and decide upon one which is not merely good enough, but as nearly as possible the best.

The Land Occupied. The ground over which a railway runs is for ever spoiled for any purposes other than a road. This is one of the serious risks of railway enterprise. In almost any other kind of commercial undertaking the land purchased can, in the event of failure, be sold without any great loss of value. Even a canal may be converted into a railway. Many have been so converted. But a railway cannot be converted into a canal. The possession of land gives to the railway—that is, to the railway organisation—occupying it, the rights of a landlord in the monopoly of its use. Such rights unmodified would afford a very strong protection against competition of all sorts. But since the land required for a railway is a long thin strip which it would in almost every case be impossible to acquire without the assistance of the Legislature, the authorities, in granting the necessary powers, are always able to stipulate for such modifications as may seem necessary for the protection of the public.

Concession or Act of Parliament. The legal enactments enabling the construction of railways are treated in PARLIAMENTARY SURVEYING [page 1109].

It is sufficient to point out here that the terms of the concession necessarily exercise a very important influence upon the general plan and details of construction and equipment. The maximum rates for passengers and for the various classes of goods are usually fixed, together with a number of physical quantities, among

which the most important are the gauge, or width of the road, the greatest permissible gradient and sharpness of curve; the minimum distance at which the trains may be allowed to pass buildings, signal posts, and other trains; the lowest height at which the line may pass over public roads and rivers, etc. Such stipulations may, and often do, materially restrict and hamper the engineer in his choice of expedients.

Nature of the Organism. An undertaking of the magnitude and national importance of a railway can very seldom be the work of one individual, but must in practically every instance be done by the public for the public. Certain members of the community will specialise themselves for the purpose, devoting as shareholders a part of their property to carrying it out, or, as employees, their time and labour to carrying it on. Others, as customers, will contribute some of their means in order to participate in the benefits it affords.

The ordinary form in which the revenue account of a railway appears shows how the services rendered and the sacrifices made by the different groups of persons are balanced one against the other, of which we give a condensed summary:

REVENUE ACCOUNT.

Dr.		*Cr.*	
	£		£
Wages and materials ..	582,000	Traffic Receipts	964,000
Dividends and Interest ..	382,000		
	£964,000		£964,000

The *traffic receipts* are contributed by customers. *Wages* (and if the railway be great enough to mine and manufacture for itself, the item *materials* also) are the remuneration of employees, while *interest and dividends* are the recompense of those who have sacrificed their property for the construction or development and expansion of the railway.

The Working Ratio. The ratio of the wages and material to the traffic receipts, obtained by dividing the former by the latter, is called the *working ratio*, and is usually presented as so much per cent. The working ratio in the present instance is 60 per cent., a very usual figure in Great Britain.

The following is a list from the principal countries for which railway statistics are available of the working ratios that obtain in each instance:

	Per cent.		Per cent.
Australia ..	68	Holland	66
Austria-Hungary	65	Ireland	62
Belgium	61	India	44
Canada	64	Italy	75
Cape Colony and Natal	71	Roumania ..	59
Dutch Indies ..	57	Scotland	54
England and Wales	63	Spain	47
France	52	Switzerland ..	57
Germany ..	65	Turkey	50
		United States ..	65

It will be seen that this most important relation is a very variable quantity. In the language of elementary algebra we may say, if R represent the traffic receipts of a railway—*i.e.*, the amount shown on the right-hand side of the revenue account, of which an example is given above—and X and E represent the amounts of the two groups of items brought together on the other side of the account, in the order given, then $R = X + E$, since the two sides of the account must balance.

The working ratio, to be represented by η, then becomes equal to $\frac{X}{R}$, and $\frac{E}{R} = 1 - \eta$, where E represents the net earnings. But it has been shown that E, the recompense for investment of capital, tends, under the influence of competition, to become a proportion thereof approximating to the rate of return upon capital invested in other business of equal standing.

This tendency may be exhibited by actually equating the two, and we have $\frac{E}{C} = \frac{J}{100}$, where J is the per cent. of the rate in question, or the value of money for commercial purposes in the country at the period considered. Multiplying both sides of this equation by $\frac{R}{E}$ we obtain

$$\frac{R}{C} = \frac{J}{100} \cdot \frac{R}{E} = \frac{J}{100} \cdot \frac{1}{1-\eta}.$$

Thus, the very important quantities R, C, J, and η constantly tend towards values the relation of which is conveniently expressed by the equation $\frac{R}{C} = \frac{J}{1 - \eta}$, where η as well as J is expressed in per cent.

In Great Britain, as a whole, the working ratio has risen from under 50 per cent. during the sixties to over 60 per cent. at the present time, this change being in a great measure accounted for by the diminished value of money, as above explained.

Cost of Construction. Before going further, it will be desirable to form some idea as to the cost of a railway. Anything from £4,000 to £60,000 or even £100,000 per mile, though true, is rather too vague for our purpose. It is important that anyone engaged in railway work, immersed in detail—as, of necessity, he usually is—should retain a clear vision of the cost of the whole, as well as its objects and function, in order that he may not be at fault in estimating the value and the relations of his particular part.

$$£ \times \text{lb.} + 10 \times \text{lb.}$$

is a formula easily remembered and applied. The symbol lb. here represents the number of pounds avoirdupois which one yard of the rail used will weigh, and the symbol £ the number of pounds sterling that the rails cost per ton delivered.

This quantity doubled will give approximately the least cost of the permanent way of a single line of railway per mile of open line in sovereigns. The formula is not intended for practical use, but merely to fix ideas. The *permanent way*

includes the rails, the chairs which support the rails, the sleepers to which the chairs are fixed, the broken stone or ballast upon which the chairs are laid, together with the bolts and other fastenings, for main line and sidings.

The *earth work*—the cuttings and embankments upon which the permanent way is laid—together with the necessary bridges, etc., will cost in a moderately undulating country about the same, and the necessary buildings and other works a similar amount. The minimum of equipment—*i.e.*, the engines and vehicles—will probably come to less, say

$$\tfrac{2}{3}\ \{\text{lb.} \times £ + \text{lb.} \times 10\}$$

But the cost of obtaining the necessary legal powers to build, and the expenses of acquiring the land, cannot be included in a general statement.

The approximation of the results of this formula to actual figures depends upon the fact that, in a well-designed railway, the weight of the rails per yard of length is to some extent a gauge as to the number and size of the sleepers taken, as well as to the amount and quality of the ballast beneath them; while the cost of the rails per ton delivered is a rough measure of the whole cost of the material utilised, as well as of the expense of doing the work. As a rule, the heavier rail is associated with a more level road, and therefore with more earth work.

According to the formula the permanent way of a single line of railway with 80 lb. rails at £6 per ton would be:

2 (80 × 6 + 80 × 10)		
= 2 (480 + 800)		
= 2 × 1,280, or ..	£2,560	per mile.
Earth work, etc. ..	2,560	,, ,,
Other works.. ..	2,560	,, ,,
Total cost of road	£7,680	,, ,,

With 30 lb. rails it would come to about half, as the cost per ton would be rather more. Neither of these figures are very far from the average results of actual working.

Estimation of Receipts. The main factor in deciding the construction of a railway is the amount of its estimated annual traffic receipts. The cost of construction comes second, as this can be modified in various ways in order to deal with the greater or less amount of traffic.

Numerous formulæ have been invented for determining the receipts to be anticipated from a proposed railway, all of which, however, have but a local, or very restricted, application.

In settled countries the density of population, or the number of inhabitants per square mile, in the district through which it is to pass is the basis in every case. In new territories the estimate involves a further estimation as to the amount of immigration and probable commercial development.

In all cases comparison must be made with other districts as nearly like it as circumstances permit, and the estimate calculated on the assumption that the local traffic receipts per mile of line will vary directly with the density of population and with the area served. The through traffic, which is derived from other railways, or the seaboard, etc., will usually be of a competitive character, and will depend upon the special facilities that can be afforded.

The chief difficulty consists in finding suitable subjects for comparison. The demand for railway accommodation depends chiefly upon the industrial development of the population. When a number of self-providing families occupy the land, there is little occasion for wholesale carriage except of passengers for pleasure. But where the land is occupied by numerous communities, each devoted to some special production, the materials for which and the results of which they exchange among themselves or with foreign countries for mutual consumption, a very high contribution per head will be made to the traffic receipts of the railways. The extent to which this specialisation of employment is carried is also dependent upon the density of population when other circumstances are similar; consequently the traffic receipts of an established railway tend to increase in a geometric ratio rather than in an arithmetic ratio to the density of population. Often the traffic receipts will be found to vary approximately with the density of population squared.

The method of estimating the probable traffic receipts of a railway by careful calculation of the output of mines and factories, etc., both actual and potential, accompanied by the detailed compilation of road statistics—*i.e.*, the number and character of passing vehicles—is extremely laborious, and no more certain than the foregoing method, since the amount of such traffic that can be diverted to a railway remains a matter of conjecture. It is, however, useful as a check upon the former.

Working Cost. It has already been pointed out that the establishment of a railway is the result of a public effort to provide a public service of locomotion. The effort is made in two ways. The first is measured by initial capital expenditure, and the second by the annual working expenses, the amount of which we shall now consider.

The chief thing to remember is that the whole aim and object of the first is to diminish the amount of the second. This point will be developed later. For the present purpose it is sufficient to note that every detail of the construction of a railway must be studied in respect to its influence upon the ultimate amount of working expenses, having regard to the kind of work—that is to say, the description of service—the railway is constructed to afford.

The railways of the United Kingdom began the present century—to take a conspicuous date—with a cash subscribed capital of almost exactly £1,000,000,000, which brought in a gross revenue of almost £100,000,000. Thus the figures of the combined revenue account for that year present themselves at once as percentages of the whole.

The expenses were as follow in thousands of pounds :

Maintenance of way and works	9,540
Locomotive power (including stationary engines)	19,288
Repair and renewal of carriages and waggons	5,173
Traffic expenses (coaching and merchandise)	19,348
General charges	2,459
Rates and taxes	3,757
Government passenger duty	330
Compensation to employees	146
Compensation for personal injuries, etc. ..	192
Compensation for damage and loss of goods	517
Legal and parliamentary expenses	306
Steamboat, canal, and harbour expenses ..	3,031
Miscellaneous working expenditure	648
Total working expenses	64,735

These heads of expenditure are those prescribed by law for this country, and require some rearrangement before they can be turned to account for our present purpose. In the words of a well-known authority: "Rates and taxes and government duty we may best strike out altogether. They represent not so much an actual expenditure as a deduction from income. Compensation ought to come in where it belongs. Compensation to an injured platelayer is properly part of the 'maintenance of way' expenditure; to an engine driver is part of 'locomotive power,' and so on. Parliamentary expenditure, if incurred in the promotion of a new line, is properly part of the capital cost of that line. If incurred in opposing a scheme believed to be contrary to the company's interest, it is a 'general charge'; or, in other words, is included in expenditure incurred, not in any special department of work, but for the benefit of the undertaking as a whole. Similarly, legal expenses should go where they belong. Fighting a claim for compensation for damage to goods is a necessary part of the cost of carrying goods; prosecuting for trespass on the line belongs to the expense of 'maintenance of way'; as would also litigation with, or drawing a contract with, a builder for station repairs, and so forth."

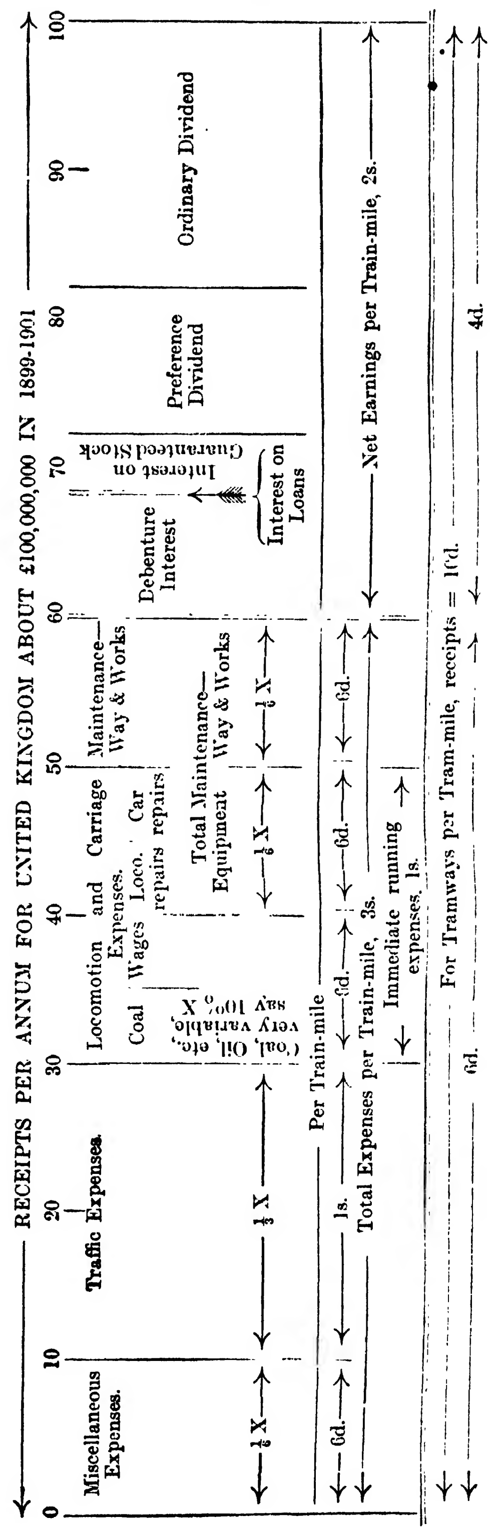
Maintenance Departments. The destination of the whole revenue of a railway company may be described as maintenance of one sort or another and grouped under four heads.

Maintenance of Physical State will comprise maintenance of the rails, fastenings, sleepers, ballast, earth work, bridges, culverts, fences, stations, signals, locomotives, carriages, waggons, etc.

Maintenance of Traffic will comprise the cost of running the trains, coal, wages of engine drivers, stokers, guards, porters, stationmasters, watchmen, signalmen, inspectors; cost of lighting, cleaning, stationery, etc.

Maintenance of the Organism will include the cost of co-ordinating the actions of the whole, and consist chiefly of expenses incurred at the head office.

Thus, all the working expenses can be distributed under these three heads, while the net earnings, which, together with these, account for



the whole revenue, are devoted to the maintenance of the proprietors, who, after paying the interest on the debts of the undertaking, have the balance for their own enjoyment. And it is usually found that if the railway cannot adequately maintain its proprietors, its proprietors will cease adequately to maintain the railway. In the scheme on the preceding page, the expenses and earnings of an English railway have been separated out and divided into aliquot parts of the whole. This gives an arrangement of figures easily understood and remembered, as well as one that closely corresponds to average conditions, the adjustments needed to divide the expenses into equal divisions being very much smaller than the deviations found in actual working.

Facts for the Constructor. The business of the builder of railroads is chiefly concerned with those items of expense included under the headings, "Maintenance of way and works," and "Locomotive, carriage, and waggon expenses." The object of a railway is to reduce the cost of transportation. A heavy capital expenditure is incurred for this purpose. A railway is so efficient a means of doing this, that when originally introduced almost any construction might be a commercial success. In these days, however, the constructor must do his utmost to ensure that such work is done, and in such a way, as to reduce the cost of transportation in working to the lowest amount possible, having regard to the kind of traffic to be dealt with and the amount of the capital expenditure required to so reduce it.

The scheme presents also the items of expenditure in amounts *per train-mile*. The meaning of this is that the amounts in every case have been divided by the number of miles that have been traversed by the trains run during the period with which the accounts of expenditure deal. The object of presenting the items of expenditure in this form is to afford a convenient means by which the cost of working on different railways can be compared with one another.

Running Expenses. It will be seen that the actual cost of running a train one mile is approximately 1s., this being the average amount of the expenditure upon oil, fuel, wages of employees on the train, repairs to locomotive and vehicles. The cost of dealing with the train-load at each end of its journey appears as *traffic expenses,* and amounts also to an average of approximately 1s. The wear and tear to the railway itself and the works—*i.e.,* buildings, etc.—that belong to it comes to about 6d. per train-mile. Adding to this the amount required to keep in repair and renew when necessary the vehicles and locomotive of the train itself, we have once more 1s. on the average devoted to maintaining the whole plant of the organism in efficient physical condition.

Physical Maintenance. The cost of maintaining the railway, buildings, and plant is obviously in a different category to that of running trains and attending to traffic, of which the remaining expenses of a railway chiefly consist. The latter will depend upon competition and public demand to a much greater extent than the former.

Quickness in despatching parcels and goods, punctuality in trains of all kinds, comfort in passenger carriages, convenience at stations, are costly means of attracting traffic, but will not affect the item now under consideration. The cost that is incurred under it will, on the other hand, depend to a very great extent upon the solidity and workmanship of the structures, on their appropriateness to the purposes they were intended to fulfil, and the skill with which they were designed.

The Minimum Conditions. Before passing to the study of construction in detail, it may be well to point out the least conditions that must be fulfilled before railway construction of any kind is justified.

The expenses of keeping a railway of the lightest description in proper repair and its equipment in a state of working efficiency will amount at least to the average wages of one man for every mile of way open. The other expenses of dealing with traffic are not likely to be reduced to less than one-third of the receipts. The minimum value of X is not, therefore, likely to be reducible to less than $w + \frac{R}{3}$ when w is the average wages of an employé. Hence, if the estimated value of R is not greater than $w + \frac{R}{3}$ by an amount sufficient to pay adequate interest on the capital required to build and equip the railway, the conditions will not suffice to justify construction at all, a railway is too ambitious a scheme, and humbler means of transportation must be adopted.

In Great Britain the minimum conditions are reached when the estimated receipts are no more than £1 per day or £360 a year per mile of line open to traffic. If the average wages of employees per head be as small as 25s. or £65 per annum, the total expenses might be brought down to $65 + \frac{360}{3} =$ £175, which, deducted from £360, leaves £185 as net earnings, thus enabling, at 4 per cent., a capitalisation of £4,625 per mile, which is less than that of any light railway in this country would be unless built in very favourable circumstances.

R. W. WESTERN

A dictionary of Technical Terms and Phrases used in Civil Engineering appears at the end of the Self-Educator

1. A Brief Introduction to the Earliest Writers of English Prose Fiction, with a Note on the Place of the Novel.

A STUDY OF ENGLISH FICTION

THAT there are in our midst today many people to whom the word "novel" is anathema indicates how invincible may become a prejudice that has once sunk deep into the public mind. For generations the novel has been a thing abhorred by a considerable section of the religiously minded; and although a more liberal view of fiction is now, for the most part, held, there still exists against novel-reading an amount of prejudice which can be maintained only by ignorance of what a novel really is. The double meaning of the word "fiction" may probably have had something to do with the continuance of an antagonism which, originating no doubt when novels were too often stuffed with scandalous "adventures" and preposterous stories, wherein lawless passions were at least displayed if not always belauded, has long since ceased to have more than occasional justification.

Prose fiction, indeed, may be the very essence of truth; in the hands of the master-writers it is truth. An historical novel, wherein the actual facts of history may be altered by the romancist to suit his story, may yet give, as a whole, a picture of the time in which its action takes place that is nearer to the life than a history that is accurate in every detail. By sheer mental vision the novelist sees and conveys to us an impression of the truth that is more vivid and lasting than that which the historian, with his procession of recorded facts, may be able to make. Thus, one could betray no greater ignorance of literature than to suggest that prose fiction was unworthy of serious study on the ground that "mere fiction" can be of no use to anyone.

Cut out the romance, the novel, and the short story from English literature, and it would be small comfort to protest that there still remained to us the history, the essay, the poem, and the drama; yes, even though these preserved a Carlyle, a Lamb, a Wordsworth, and Shakespeare! Our prose fiction must be accounted one of our greatest national treasures; and no matter how contemptible some modern novels may be, they are but unworthy specimens of a magnificent literary form to the standard examples of which we counsel both student and general reader to give serious consideration.

The great novel is, in a word, one of the indispensable means of modern culture. Jane Austen's description of the novel as it should be can hardly be improved upon. A novel, according to this charming exponent of one phase of the art of fiction, is a work "in which the greatest powers of the mind are displayed, in which the most thorough knowledge of human nature, the happiest delineation of its varieties, the liveliest varieties of wit and humour are conveyed to the world in the best chosen words." And did not R. L. Stevenson write: "The most influential books, and the truest in their influence, are works of fiction. They repeat, they rearrange, they clarify the lessons of life; they disengage us from ourselves, they constrain us to the acquaintance of others, and they show us the web of experience, but with a singular change—that monstrous, consuming *ego* of ours being, for the nonce, struck out"?

When worthy of the name, the novel combines the essential qualities of drama and poetry; when perfectly fashioned, it is as much a work of art as a statue by Phidias or Praxiteles, or a painting by Raphael or Titian, and it demands and deserves to be judged accordingly. Some of the greatest men have sought relaxation and found inspiration in reading and in writing novels. If time is wasted over works of fiction the blame must attach only to the quality of those that are read, and the carelessness of the reader in his choice.

It is too frequently forgotten that novels, as a form of art, must be regarded as we regard dramas and poems. Drama is composed of two main divisions, comedy and tragedy, but each of these divisions has many subdivisions; and the quality of a play is to be judged by its relation to the standard of its particular division. This is the case with the poem and its relation to what we understand by the epic, the

narrative, and the lyrical standards, as we have already learned in previous studies. What is true of the play and the poem is true of the novel, with this proviso: that the novel is susceptible to more numerous gradations, and still more intricate classification.

The late Sir Leslie Stephen once defined the artist as one whose main purpose it is to receive impressions of images the reproduction of which may make this world a little better for us all. This description of the artist is absolutely true of the writer of novels who is a novelist in deed as well as in name.

Aids to the Study of Fiction. But here comes the difficulty for the student, at whatever age he may approach the theme, as the field covered is so vast. The phrase "the world of fiction" is no idle figure of speech. The student of fiction needs chart and compass no less than the traveller in an unknown country; without them, inevitably he will have more to regret than mere waste of time. Let him therefore begin by consulting carefully some good map of the country he proposes to explore. In other words, let him at the outset of this branch of study secure some sound knowledge of the history of the subject as a whole, so that he may not fall into the error of accepting fiction as mere "reading for an idle hour." For a short study of the subject we know of nothing better than David Masson's brilliant lectures: "British Novelists and their Styles: Being a Critical Sketch of the History of British Prose Fiction" (1859). Another invaluable and more easily procured work is Professor Walter Raleigh's "The English Novel: Being a Short Sketch of Its History from the Earliest Times to the Appearance of 'Waverley.'" B. Tuckerman's "History of Prose Fiction" (1882), Sidney Lanier's "The English Novel and the Principles of its Development" (1883), and W. J. Dawson's "Makers of English Fiction" (1905) are also useful.

The student who has mastered these books, or even the first, second, and last named, will be in a position to make that choice upon which the profitable study of particular periods or writers depends. Much that is of real service will be found also in Jonathan Nield's "Guide to the Best Historical Novels and Tales" (1904); Elizabeth Lee's able translation of M. Jusserand's "The English Novel in the Time of Shakespeare" (1901); Nassau W. Senior's "Essays on Fiction" (1864); the Hon. A. S. G. Canning's "History in Scott's Novels" (1905); Walter Frewen Lord's "The Mirror of the [Nineteenth] Century" (1906); and Sir Walter Scott's "Essay on Romance."

The Origin of the Novel. It does not fall within the scope of this short study of the beginning of English fiction to trace the origin of the novel back to the dawn of folk-lore and legend. There is no trait in human nature more universal than the love of story-telling and story-hearing. The first of novelists were undoubtedly the professional story-tellers of the East. The old tales and legends and romances, from which the modern novel has sprung, passed from one generation to another by word of mouth. Their history is akin to that of the Hindu Scriptures. One example may be quoted as evidence of the love of the story and of its utility: the interest awakened in the young by the stories and parables of the Bible. Modern research has discovered novels in the brick libraries of Babylon and in the inscriptions on Egyptian papyri.

Professor Flinders Petrie, the archæologist, for instance, in his "Egyptian Tales," has this noteworthy comparison: "It will be noted how the growth of the novel is shadowed out in the varied ground and treatment of the tales (dating from 4000 B.C. to 1000 B.C.). The earliest is purely a collection of marvels or fabulous incidents of the simplest kind. Then we advance to contrasts between town and country, between Egypt and foreign lands. Then personal adventure, and the interest in schemes and successes, become the staple material; while only in the later periods does character come in as the groundwork. The same may be seen in English literature—first, the tales of wonders and strange lands, then the novel of adventure, and lastly the novel of character."

Influence of Foreign Writers. In a European sense, as Emerson says, every novel is a debtor to Homer. Indebted to the "Iliad" and the "Odyssey," it is also beholden to Italian influence and example. Though the point is as elusive of settlement as the origin of the English drama, the fact that the word "novel" is derived from an Italian root favours the theory of the descent of this branch of English literature from the intercourse between England and Italy in the fourteenth century. One of the fathers of the novel is certainly GIOVANNI BOCCACCIO (b. 1313; d. 1375), who was one of the first of the moderns to give to popular tales the graceful garb of prose fiction. But English commerce with Spain and Portugal in the sixteenth century is a factor in our literature that cannot be overlooked. So with Homer and Boccaccio we must place MIGUEL DE CERVANTES SAAVEDRA (b. 1547; d. 1616) among the potential fathers of English fiction. Nor must we forget the influences of the Norman Trouveurs, of the chivalric legends of Alexander, Charlemagne, and King Arthur, and of the satirical fiction of FRANÇOIS RABELAIS (b. 1483; d. 1553).

The points are admirably and lucidly dealt with by Professor Masson, who notes as of special significance the dates of the following translations into English (we have already drawn attention to the wealth of English translations in our study of English Prose): Part of Boccaccio in 1556, followed by Cintio's "Hundred Tales"; the "Golden Ass" of Apuleius, in 1571; the "Æthiopica" of Heliodorus, in 1587; Mendoza's "Lazirallo de Tórmes," by David Rowland, in 1586; the "Diana" of Montemayor, in 1598; "Don Quixote," first in 1620; and Rabelais, by Urquhart, in 1653. The deduction is that the

novel of adventure and gallantry, the pastoral romance, and the picaresque novel (or novel of roguery, of Spanish origin) may have been naturalised in Britain by the beginning of the seventeenth century.

The First Original Novel in English. Meanwhile England had produced a form of prose fiction which was indigenous. The outstanding examples were the Latin allegories of More ("Utopia," 1516), Barclay ("Argenis," 1621), and Bacon ("New Atlantis," 1627). In 1579-80 appeared "Euphues," the first original prose novel written in English. The author of this work was JOHN LYLY (b. 1553; d. 1606), of whom as a dramatist we heard on page 594. The story is quite uninteresting to the modern reader, but the style in which it was written suggested a new word, "euphuism," and promoted a form of popular "polite" dialogue the influence of which is traceable in Shakespeare (*cf.* Adriano de Armado in "Love's Labour's Lost," and Malvolio in "Twelfth Night"); Ben Jonson (Puntarvolo in "Every Man out of His Humour"), and Sir Walter Scott (Sir Piercy Shafton, in "The Monastery"). Lyly has been unduly despised and much misrepresented. His importance as one of the first writers of witty prose dialogue in English is the chief fact in regard to him that the student of literature has to bear in mind.

Elizabethan Prose Fiction. Next to Lyly's "Euphues" the posthumous "Arcadia" (1590) of SIR PHILIP SIDNEY (b. 1554; d. 1586) claims attention. Indebted as Sidney was to foreign influence, and particularly to the Italian Sannazaro and the Portuguese Montemayor, both disciples of Boccaccio, his pastoral romance enshrines true passion and has a ring of chivalrous sincerity that is absent from "Euphues." Sidney borrowed, but gave also. French and English writers felt his influence. Shakespeare is one of his debtors, and Professor Raleigh points out that Richardson is "the direct inheritor" of the analytic and sentimental method in romance which Sydney developed. The "Arcadia," as Professor Raleigh observes, "is in some sort a half-way house between the older romances of chivalry and the long-winded 'heroic' romances of the seventeenth century.

The Earliest English Picaresque Romance. "Action and adventure are already giving way to the description of sentiment, or are remaining merely as a frame on which the diverse-coloured flowers of sentiment may be broidered." The student will find a great deal to interest him in the writings of ROBERT GREENE (b. 1560 ? d. 1592); THOMAS LODGE (b. 1558 ? d. 1625), whose "Rosalynde" (1590) inspired "As You Like It"; and THOMAS NASH, (b. 1567; d. 1601), whose "Unfortunate Traveller" (1594) is cited as the earliest example of a picaresque romance in English literature, and who is the immediate forerunner of Defoe.

Allegory, Romance, and Religion. Of course, Chaucer, a contemporary of Boccaccio, was really one of the first of English storytellers. The "Canterbury Tales" are full of wit, humour, knowledge of life, and generous tolerance, but Chaucer, like the later writers to whom we have been referring, wrote primarily for the Court and the Universities. "The Pilgrim's Progress," written by JOHN BUNYAN (b. 1628; d. 1688) in Bedford gaol, and published in 1678, was addressed to the simple understanding of the "common people." It is the first great popular allegorical narrative in the language, and its history provides a permanent moral for all writers who seek to influence their fellows by the use of the pen. Twenty years after the appearance of "The Pilgrim's Progress," two works by MRS. APHRA BEHN (b. 1640; d. 1689), "Oroonoko" and "The Fair Jilt," were published posthumously. With these works the novel of contemporary life may be said to have begun. "The Fair Jilt" is of little importance; "Oroonoko" anticipated Rousseau. But heroic and pseudo-chivalric romance had lost its savour.

Prose Fiction of Defoe and Swift. Then came DANIEL DEFOE (b. 1661; d. 1731), one of the greatest realists in English letters. With him the art that conceals the author from the reader, and induces the reader to believe that what he is perusing is a transcript from unquestionable first-hand evidence, attained a standard that has been but seldom, if ever, excelled by later writers. The world-famous "Life and Strange Surprising Adventures of Robinson Crusoe, of York, Mariner" (1719) is Defoe's finest work, but his "Moll Flanders," "Colonel Jack," and "Roxana" are still read as typical examples of the Newgate Calendar novel at its best. The realism of "Robinson Crusoe" finds a counterpart in "The Travels into Several Remote Nations of the World by Lemuel Gulliver" (1726-1727), of JONATHAN SWIFT (b. 1667; d. 1747). In neither work, it will be observed, is any great appeal made to the emotions. The student should also take special notice of the association of Defoe and Swift with the pamphlet and the newspaper.

It is an interesting speculation whether the newspaper, foster-parent of the novel as it has proved, may not one day itself supersede the novel. The journalistic work of Defoe and Swift has been already referred to; but in passing to the first of the great English novelists another fact worth mention is the influence of such publications as the "Tatler" (1709-1711) and the "Spectator" (1711-1712) on the formation of a public taste which it was the destiny of Richardson, Fielding, Sterne, Smollett, and Goldsmith to satisfy. The rise of the novel as distinct from the romance and the allegory has pursued lines that are almost parallel with the progress of the woman's movement. This point is mentioned as suggesting a promising line of study.

J. A. HAMMERTON

Diplomacy as a Career. Attachés and Foreign Office Clerks. King's Messengers. Consular Appointments. Interpreterships.

FOREIGN OFFICE CAREERS

All the posts of various grades that come within the scope of the present paper are controlled by a most important Department of State—the Foreign Office. Under the direction of a Parliamentary Secretary of State for Foreign Affairs, this branch of the public service is occupied, as its name indicates, with the relations existing between our own and foreign countries. The functions involved are broadly of two classes. Of these the first comprises our political interests—the representation of Great Britain at foreign courts, due enforcement of our prestige, the making of treaties, and the maintenance of such terms with each nation as are dictated by our foreign policy. All these matters are entrusted to our Diplomatic Service. Commercial and non-political interests, on the other hand, come under the care of the Consular Service. These two divisions of Foreign Office work are not always separate in practice, but for convenience they are separately discussed here.

For either division the nomination of the Foreign Secretary is essential. Private influence is no longer necessary to secure this, but it is reserved for men whose education and personal qualities are approved by a Board of Selection. They must be natural-born British subjects, "born within the United Kingdom of parents also born therein."

The Diplomatic Service. Political diplomacy as a career is carefully reserved for the elect men. Aspirants must be of high social rank and liberal education, who have given promise of special abilities to fit them for the intricate and delicate rôle of the diplomat. The most ardent supporter of the principle of unrestricted competition as a means of recruiting our public services will, we believe, be convinced on reflection that such a system, however admirable in itself, would be out of place in the Diplomatic circle. For that calling, while brains are invaluable, the ability to pass examinations is comparatively unimportant. The type of officer required is not the bookish student, but the clever, well-educated man of the world, who is also, in the conventional sense of the term, a polished gentleman. The supreme essentials for success, in fact, are tact and shrewdness, a wide knowledge of men and affairs, and such a social standing and personal address as will procure an entry into the highest circles of any foreign capital to which the diplomatist may find himself appointed. And such qualifications are best secured not by competitive examinations, but by personal selection among the scions of our leading families, from which class the members of our Diplomatic Service are generally drawn, in fact.

Attach's and Foreign Office Clerks. Would-be diplomats who are fortunate enough to obtain a nomination from the Foreign Secretary compete, as vacancies arise, for the interchangeable appointments of junior clerk in the Foreign Office and attaché in the Diplomatic Service. From half a dozen to a dozen such vacancies are offered each year, and are contested by three or four times as many candidates, who must be between 22 and 25 years of age. These take part, under special conditions, in the examination for Class I. clerkships held every August. [Particulars of this examination were given on page 2055.] As is natural in selecting men for a service involving residence in the various European capitals, great importance is attached to proficiency in modern languages. They are required to pass in French and German, and are officially notified that they "must reach a high qualifying standard in translation, composition, and oral examination in both these languages," and that Spanish may be taken as an alternative to Italian. The subjects chosen from the schedule must not carry a greater maximum than 4000 marks. With these modifications the Class I. scheme applies.

Salaries and Prospects. Successful candidates who enter the clerical staff of the Foreign Office enjoy practically the same advantages as Class I. clerks, rising rapidly to £800 or £1000 a year, with special allowances for translating and other work, and some prospects of higher posts. Those who are destined for a diplomatic career must have an income or allowance of £400 a year at least, as they are required to serve for some years on honorary or merely nominal terms. Their ultimate prospects, however, are more brilliant and distinguished than any other branch of the public services can afford. They are first appointed on probation as unpaid attachés for two years, and then receive commissions as third secretaries at £150 a year. This amount may be augmented by special allowances of £100 each for proficiency in the native language and in public law. On promotion to the grade of second secretary they are paid £300, rising to £450, and after seven years' service in that rank become first secretaries at £500 a year.

From this point advancement is rapid to the foremost positions; but as the salary and status of a British representative abroad vary with the importance of the country in which he serves, no strict classification is possible. Councillors receive from £500 to £1000 a year, ministers and envoys between £1300 and £5000, and ambassadors from £5500 to £11,500. In Peru and Venezuela, for instance, we are represented by

ministers-resident at £2000 a year each, in Portugal by an envoy-extraordinary and minister-plenipotentiary at £3750, while in the capitals of such first-class Powers as Germany, Turkey, and Russia we have ambassadors stationed who receive for their services from £7800 to £8000 a year. The premier position in the service—that of British ambassador in Paris—is held by a distinguished diplomatist who began his career as a Foreign Office clerk.

Student Interpreterships. This grade was created in order to supply his Majesty's missions and consulates in the East with trained officials, speaking and writing the native languages, and competent to perform the legal and other duties of consular officers. It is, of course, imperative that the man selected should have considerable aptitude in acquiring languages, for which reason foreign tongues are prominent among the subjects fixed for the entrance con-

A VIEW OF THE FOREIGN AND INDIA OFFICES FROM ST. JAMES'S PARK

tests. The requirements as to physical health are specially severe for this service.

For interpreterships in the Near East—the Ottoman Empire and neighbouring lands already named—the examination scheme and the subsequent training differ very materially from those prescribed for the joint service of China, Japan, and Siam.

Interpreters in the Near East. For the Turkish dominions, Persia, Greece, and Morocco, student interpreters are selected from among nominated candidates between 18 and 24 years old by means of competitions held each August. Very few vacancies are offered at a time, the number in recent years having never been more than six. Luckily, the candidates are also few. They rarely much exceed a dozen, several of whom usually fail in Latin or French. Such a small attendance is due to the fact that very few men are sufficiently expert linguists to face an examination in six foreign languages at once. That formidable array of alien tongues awaits aspirants for the Near Eastern service; and although four of the half-dozen are nominally optional, a glance at the accompanying

King's Messengers. A small force of Foreign Service messengers is employed for the conveyance of confidential despatches between headquarters and the embassies. This work is responsible and sometimes not free from perils. The messengers are therefore chosen with the utmost care from among skilled horsemen of hardy frame and proved courage and devotion. Several of them have held commissions in the Army. They are paid from £250 to £400 a year. Candidates must be between 25 and 35 years of age, with a good colloquial knowledge of French, German, or Italian. When actually bearing despatches the King's messengers wear a picturesque badge—a silver crown and greyhound suspended by a blue ribbon.

The Consular Service. Apart from honorary consulates and those held by traders, the Consular Service is maintained by means of examinations of three classes. Of these the first is for student interpreterships in the Ottoman dominions, Persia, Greece, and Morocco; the second for similar positions in China, Japan, and Siam; and the last for general consular posts other than interpreterships.

table, which includes the results of a recent test, will show that a competent knowledge of each is essential for success. The examination fee is £4.

The test in French is severe, including translation from and into the language, dictation, writing a letter in French, and conversation — paying particular attention to accent, genders, and tenses. In all, the various foreign languages are responsible for no less than 2300 in a total of 3000 marks.

Students who are declared successful at these contests are sent to a university on probation for two years, pursuing there a prescribed course of studies in Oriental tongues and spending a month of each year in France. During the term of residence they receive a salary of £200 a year, subject to their passing their examinations from time to time. On quitting the university they are appointed as assistants at a salary of £300 a year, and are despatched to a British consulate or legation in the East. Twelve months later they are examined in the language of the country in which they reside, and after a further interval must pass an examination in the language and history of that country.

Thenceforward the much-examined consular servant is suffered to pursue his career without further molestation. It is a fairly but not extravagantly remunerated calling. On becoming a vice-consul, the ex-student interpreter receives from £350 to £500 a year, with fees and allowances which are in some cases very substantial. The higher grades of consul and consul-general carry salaries ranging up to £1250, in addition to allowances as before; and for those who win the special favour of the authorities at the Foreign Office there are chances of transference to still better-paid posts.

The Work of a Consul. The consul is too frequently looked upon solely as the stand-by of the traveller in difficulties in a foreign land, but, apart from looking after the interests of her subjects, his chief function is that of commercial intelligence officer to the country he represents. In this capacity he compiles trade reports embodying all manner of information and statistics relating to trade, new openings for trade, new routes of communication, shipping and exchange, that may be of use to the merchants he indirectly represents. Many of these reports —too often unread by the general public—prove of remarkable interest and no little value, and they afford considerable scope for the display of initiative and ability on the part of the consul.

The Far Eastern Service. Men selected to compete for student interpreterships in this service must be at least 21 and under 24 years old. Like candidates for the Diplomatic Service, they attend the Class I. examinations described on page 2055. Sanscrit and Arabic are excluded for them, and not more than two natural sciences may be taken. In French, which is obligatory, a high standard must be reached in translation, composition, and conversation. With these restrictions, any subjects may be taken, up to a maximum of 4000 marks, but each branch of mathematics carries only 600 marks, instead of 1200.

On passing the examination, student interpreters proceed directly to China, Siam, or Japan, where they spend a probationary term in studying the native language, receiving meanwhile an allowance of £200 a year. On completing their studies they are appointed as third-class assistants in a consulate at a salary of £300. Thence they progress through the grades of second and first-class assistants (£350 and £400), and vice-consul (£600 and £700), to the leading position of consul (£800 to £1200). The abler linguists among the assistants receive special grants for interpreting and translating duties; and in the higher grades there are liberal allowances of various kinds.

EXAMINATION FOR STUDENT INTERPRETERS: TURKEY & NEAR EAST

Order of Merit.	Obligatory.					Optional.				Total.
	Arithmetic.	Reading aloud, Handwriting and Orthography.	English Composition.	French.	Latin.	Greek (Ancient).	Italian.	German.	Spanish.	
Max.	300	200	200	600	400	400	300	300	300	3000
No. 1	285	143	140	533	305	323	282	255	190	2465

General Consular Appointments. In 1904 the Foreign Secretary formulated a general scheme for recruiting the Consular Service by the admission of nominated candidates other than student interpreters. Anxious to attract young men of good standing and of some legal or commercial training, the authorities announce that any of the following qualifications will be of service to candidates when seeking the Foreign Secretary's nomination: admission to the Bar or as a solicitor, a university degree, or three years' experience in a commercial house.

The age limits for candidates are 22 and 27. Persons nominated to compete are examined in English, French, either German or Spanish, and in commercial law, arithmetic, commercial geography, and political economy, and must qualify in every paper. A detailed syllabus of these subjects can be obtained on application to the Under-Secretary of State, Foreign Office, S.W.

On passing their examination, candidates are at first employed for several months in the Foreign Office and the Board of Trade, to learn the methods of business in those departments. They then proceed to their posts abroad, at a salary of £300 a year, with £20 yearly increments up to £500. After a year's foreign service they are expected to know enough of the local language to be able to communicate directly with the natives. This test being met, the consular officers become eligible for advancement in the same way as are student interpreters.

ERNEST A. CARR

Professor Bateson's Explanation of Mendel's Law.
The Transmission of Eye-Colouring and Disease.

MODERN MENDELISM

In the year 1900, when Darwin had been dead for eighteen years and Mendel for sixteen, three botanists, working independently, obtained remarkable results from breeding experiments, and a search was made to find whether anyone had previously noted any such results. Thanks to one entry in a long bibliography, Mendel's paper of a generation earlier was looked up, and his great discovery discovered. The new or "neo-Mendelian" epoch thus closely coincides with the course of the present century.

The Application of Mendel's Law. The accuracy of the facts was at first seriously contested, but the repetition of Mendel's experiments put them beyond question. It was next asserted that these results were of no wide or general significance, seeing that they were only concerned with hybridisation, quite artificial and irrelevant to the problems of organic evolution. Further inquiry showed that the Mendelian law applies to hosts of cases where there is no question at all of hybridism. Within the limits of a single species, or even a single variety, individual differences or variations occur which can be shown to obey Mendel's law in their transmission.

It was next asserted that Mendel's law, which clearly applied to notable cases of colour in plants—for instance, in sweet-peas—did not apply to animals at all, as was instanced by the case of coat-colour. But observations made in the proper way soon showed the vastly important truth that Mendel's law is not confined to the vegetable kingdom, but *obtains among animals also.* Today there is no question as to whether we are dealing with a vegetable or an animal form of life when studying Mendel's law. That law and its various complications are illustrated alike in both kingdoms of the living world, thus furnishing, of course, another and striking instance of their essential unity, and of the "uniformity of Nature."

Colour Transmission. Colour, indeed, is one of the most easily studied of characteristics, and there is none which more regularly obeys Mendel's law. It has already been noted that when the records of the stud-book were, for the first time, examined in the right or Mendelian way, which takes account of each individual's mating, the offspring of two chestnuts were found to be always chestnuts also. In other words, chestnut in horses is a Mendelian recessive. Various other colours, due to the overlaying of chestnut, so to say, with something else, have now been analysed, and in the newspaper accounts of the grey colour of a certain famous racehorse Mendelian terms were used, and we were told how he inherited the "factor" for grey from his father, and how certain other factors were liable to "inhibit" the development of grey, as of the chestnut colour.

To discuss the actual details of colour-transmission, whether in plants, as in the typical case of the sweet-pea, or in animals, as in the typical case of the horse, would occupy many pages of analysis and formulæ, and is unnecessary here [see page 1756]. For the details of many of the innumerable cases where the Mendelian system of transmission has been worked out, the reader should consult either the standard work on the subject, Professor Bateson's "Mendel's Principles of Heredity," of which a revised third edition has lately appeared, or the most convenient text-book for the student, Professor Punnett's "Mendelism," which is short, trustworthy, and much easier reading.

The violent and deplorable controversy which followed upon the re-discovery of Mendelism is now ended in the eyes of the scientific world. Allegations of bad faith against the Mendelians, that they miscounted their experiments so as to appear to obtain the expected Mendelian ratios, and so forth, were freely made, but the widespread repetition of such experiments has put an end to that period.

The Leader of Modern Mendelism. From the first, until the present day, the leader of modern Mendelism has been Professor William Bateson, F.R.S., who is now the President-Elect of the British Association. To him we owe the useful term *genetics*, which he himself defines as "the physiology of heredity and variation," and of which Mendelism is, as we must carefully remember, not the whole but an important part. In 1908 Professor Bateson was appointed to the newly founded Chair of Biology at Cambridge, and his inaugural lecture, entitled "The Methods and Scope of Genetics" (Cambridge University Press), is a masterpiece of clear exposition, and constitutes the best possible introduction to modern genetics. That Chair is now extinct, but its place has been taken by the Arthur Balfour Chair of Genetics, which will be permanent, and was founded by Mr. Balfour in memory of his distinguished brother, a student of embryology. Professor Punnett holds that Chair, while Professor Bateson is now Director of the John Innes Horticultural Institution at Merton, Surrey, where he carries on extensive breeding experiments.

Mendelism Applies to Man. But the observation may here be made that in this country we now urgently require a Chair of *Human* Genetics, an immense and all-important subject which can only receive a small fraction of attention in Cambridge at present. For the final point that requires to be made, in tracing the extension of Mendelian studies, is that they are

now known to be relevant—not merely to animals as well as plants, but *to man himself*.

This was long and strenuously denied, and, indeed, the importance of Mendelism would have been far less if man had proved an exception to it. The argument was advanced that, in the familiar and relatively simple case of *colour*, where Mendelism was asserted to apply in many plants and animals, it certainly did not apply to man, for when black and white are mated the offspring are mulatto, a blend of, or compromise between, the parental characters, and showing no sign of Mendelian segregation.

Skin and Hair Colouring. But, in fact, this criticism was much too hasty, and omitted to inquire carefully into the offspring of mulattoes, when mated among themselves. The particular case is not simple, because it is almost certain that the colour of the negro depends, as in so many other cases, upon the existence of more than one "factor," but recent observations are clearly beginning to solve this problem of human skin-colour, its inheritance, and hence its "factorial" constitution, on Mendelian lines.

In another case of colour, however, Mendel's law has been proved to apply to man, this being the first instance of such application, and still one of the very few which have been proved, within the realm of the normal. Certain characteristics of hair-colour, and of the form of the hairs—straight or "frizzy"—and right and left handedness, practically complete the list of *normal* Mendelian characters in man, so far as research has gone at present.

Eye Colouring. But the first case, that of eye-colour, is the most striking and interesting. In all but albinoes, whose bodies are practically devoid of all normal pigment, the iris of the eye is coloured in various ways and degrees, and we call the eyes brown, hazel, or blue accordingly. It was first proved by Major Hurst, who personally examined all the inhabitants of an English village, and was then confirmed by Davenport in the United States, that the brown eye is dominant and the blue recessive.

Anatomical observation shows the simple fact that the blue eye has pigment deposited upon the *back* of the iris, but practically none upon the front. The brown eye has pigment upon both the front and back of the iris. Mendelian study of three human generations or more showed that the ordinary rule is observed. Two blue-eyed parents have only blue-eyed children, because RR × RR can only yield RR. On the other hand, just as in the case of Mendel's peas, there are two kinds of brown eyes, the pure and impure dominants. Therefore, dark-eyed persons may have families *all* dark-eyed or families composed of a mixture of dark and light eyed children in certain proportions, which, on the average, are definite.

To this general rule there may be excessively rare exceptions, which, of course, mean something, and must be sedulously studied. But the case illustrates, above all, the importance of the right method in science, and the truth of Bacon's teaching that the great business of philosophy is simply to teach us how "rightly to put the question to Nature." Many discoveries depend on the invention of wonderful instruments, like the spectroscope, but here is one which Aristotle could have made, or anyone else, without any instrument beyond a pair of ordinary eyes. The facts lie on the surface, and immediately reveal themselves when they are properly looked for—but not till then. Later, we shall learn that many abnormal or morbid characters in man are also Mendelian, and that their appearance or disappearance can accordingly be predicted or controlled. This is obviously a matter of enormous importance for eugenics, which depends upon the application of biological laws to the human problem, but we must do no more than note that tremendous possibility here.

Disease and Heredity. The immediate fact before us is that many students had devotedly studied the heredity of disease in man, had accumulated immense stores of data, and had entirely failed to reach precise or available conclusions. Deaf-mutism is a representative instance. The devotion and patience of Graham Bell—whose name is famous in connection with the invention of the telephone—and of others in lesser degree, are beyond praise. They showed that there is some real connection between deaf-mutism and heredity, but they could not tell us what it was, nor predict the results of any particular mating. Yet their data ran into tens of thousands.

Within the last three years, Dr. Kerr Love, of Glasgow, having the Mendelian key as an essential part of his equipment, as his predecessors had not, and scrupulously following the lines set by Mendel in connection with a problem apparently so remote, half a century ago, evolved order from the chaos of the data, and proved the existence of a Mendelian form of deaf-mutism. That is clearly of eugenic significance, but its importance for us here is in the testimony it affords to the reality and the wide relevance of Mendel's discovery, and the incalculable importance of his scientific method.

We close this historical part of the discussion, therefore, by noting the extension of Mendelian principles, from plant hybrids to plants that were not hybrids, from plants to animals, and from animals to man, in several instances of health and of disease. Even as we here read and write, investigations in many lands are extending the list of Mendelian cases throughout the whole range of bi-sexual life, and including the normal and the morbid in plants and animals as well as man. Thus we know, and must later consider, Mendelian forms of disease, or susceptibility to disease, which comes to the same thing in effect, in wheat, just as we know of Mendelian forms of disease, such as colour-blindness, hæmophilia or "the bleeding disease," one form of deaf-mutism, and a list of scores besides, in man.

The Presence and Absence Hypothesis. The general bearing of Mendel's law having been established, we need to make inquiry into its meaning. Mendel, as we have seen, introduced

the terms *dominant* and *recessive*, and gave us the idea of contrasted factors. But the simple and invaluable explanation of this first fact of Mendelism has been furnished by Professor Bateson. His interpretation was called by himself the "presence and absence hypothesis." It asserts that the recessive character, such as the shortness in the pea, depends upon the absence of something which, if present, would make the pea tall. We do not need, therefore, to puzzle ourselves over this contrast between characters, and to wonder why there should be a factor for tallness and a factor for shortness, which go into equal numbers of the germ-cells produced by an impure dominant. The facts do not require such an expression. Instead, we have the idea of a single factor, the result of the presence of which is to make the individual tall, while if the individual does not possess this factor that individual must be short.

All the Mendelian facts which we have hitherto described can be readily interpreted with this simple key. The recessive, such as the dwarf pea or the blue eye, is due to the absence of the factor for tallness or brownness of eye respectively. Mate any two such recessives, and all their offspring must be recessive, too; the factor for the dominant character was absent from the constitution of both parents, and therefore there is nowhere for the offspring to get it from. And, clearly, there can be only one kind of recessive.

Dominants and Impure Dominants. On the other hand, there must be two kinds of dominants, as we already know, but now we can describe afresh and give a real meaning to their respective symbols, DD and DR. The predominant, DD, has the factor from both parents; it has what Bateson himself conveniently calls a "double dose" of the dominant factor. All its germ-cells, accordingly, are of one kind in this respect, containing the dominant factor also. Each of them is to be represented as D, and the character of the new individual depends on whether the D germ-cell meets another D germ-cell, to make a pure dominant, DD, or a germ-cell R to make an impure dominant, DR. This impure dominant, on our theory, has received a dose of the factor from one parent but not from the other. It has only a "single dose" of this factor in its composition. Its germ-cells correspond to its constitution; on the average, half of them will contain the dominant factor, and half of them will be without it, and hence will be what we have hitherto called recessive.

The theory makes clear the reason why dominant and recessive factors apparently cannot live in harmony in a single germ-cell, and why, if one of them enters the germ-cell, the other is excluded. There is really no recessive factor. The only factor concerned must either be in the germ-cell, which is accordingly dominant, or not in the germ-cell, which is accordingly recessive. Bateson has been abundantly justified in saying, six years ago, that this conception of presence and absence is "the basis of all progress in genetic analysis."

The Dominant Factor in the Human Eye. Taking the case of our own eyes, let us note an extremely interesting and really simple complication, if we may say so. Everyone knows that there are at least two kinds of brown eyes. One kind is dark brown, the iris being all of the same colour, and opaque. Another kind is a brown eye also, and certainly not blue, but the colour is less intense, and is often distributed differently, so that the part of the iris next the pupil is really brown, while the part further from the pupil is blue or green.

Such eyes are very often called hazel, and there is a real genetic difference between the dark brown and the hazel eye. It is perfectly simple. The dark brown eye is DD. The dominant factor has come in from both parents, and the individual has a double dose of it in him, and is accordingly a pure dominant or pure bred in this respect. But the hazel eye is DR. The dominant factor has come in from one parent only, and the individual has only one dose of it in him. In this respect he is an impure dominant or cross-bred. Technical terms are necessary, and we may call the pure dominant, or the (pure) recessive, *homozygous*, or like-yoked, while the impure dominant, which has received a factor in one germ-cell but not in the other, is to be called *heterozygous*, or unlike-yoked, to translate the Greek into English.

We say that these brown and hazel eyes are a complication, because nothing of the sort was noticed in Mendel's peas. There no one could distinguish the tall peas which only had tallness in their ancestry and themselves, from those which had a short parent. The impure dominants, with only one dose of tallness, were as tall as the pure dominants, with two doses. That is the typical case. But there are many where the features of the individual vary according as it has two doses or one of the dominant factor; and in such cases the pure and the impure dominant can be distinguished on personal inspection, as well as by the only means of distinction which we have in other cases—by breeding from them and noting the characters of the offspring, and their offspring.

The Children of Hazel-Eyed Parents. It is, of course, of great theoretical and æsthetic interest to note the hazel eyes of all the children of a pure brown-eyed and a blue-eyed parent. It is of no less interest to note the eye-colour of the children of two hazel-eyed or impure dominant parents. We now know what kinds of germ-cells, in this respect, each of those parents is producing; and when we go back to Mendel's first experiment, and recall what happened when his cross-bred tall peas were mated, we shall realise that the children of such parents, if they be four in number, will, on the average of many families, according to the laws of chance, be DD, DR, RD, RR. In such a family, in other words, we may expect to find one child with dark brown eyes, such as neither parent has, one child with blue eyes, such as neither parent has, and two children with haze eyes, like their parents.

Another terminology is often employed nowadays, especially by the American Mendelians. It assumes the truth of Bateson's interpretation of Mendel's law, and accordingly describes individuals as respectively *duplex*, *simplex*, or *nulliplex*, in a given respect, according as they contain two doses, one dose, or none of the factor under discussion. On this rating, the true brown eye is duplex, the hazel eye is simplex, and the blue eye nulliplex. These terms are convenient, and they, or some others, come to be necessary when we find cases where the duplex and the simplex, the pure and the impure dominants, are distinguishable personally, as Mendel's peas were not.

Professor Pearson's Criticism. Much criticism has been passed by Professor Karl Pearson and the few remaining opponents of Mendelism on the ground that *all gradations* between, for instance, the hazel and the blue eye may be observed. Even upon the front of the blue iris minute traces of pigment may be found with the microscope, though none can be observed during life. Hence it is argued that the alleged sharp and genetic differences between these various kinds of eyes are unreal.

Such critics have forgotten the factor of nurture, which every characteristic of every living thing requires. The genetic factors give only potentialities. According to the degree of appropriate nurture will those potentialities be realised. Accordingly, all shades of brown eyes may be seen, depending upon variations in nurture, superposed upon the two genetic varieties, duplex and simplex, which we have just studied.

The Important Factor of Nurture. Light is apparently the most important and variable factor of nurture in this connection. That, at least, is the answer to the critics which is here offered, and which was first suggested by the remarkable observation of Sir Ernest Shackleton that, after many months of Antarctic night, all fifteen men of his shore party had blue or grey-blue eyes. The genetic difference between those eyes could only be revealed in the presence of light, which would cause the development of pigment upon the front of the iris in some, according to its degree, but not at all in those whose eyes were recessives in this respect.

A Suggestive Theory from America. Lastly, on this point, be it noted, with caution, that some recent American observers think they found a difference between duplex, simplex, and nulliplex human beings in respect of certain nervous conditions. The nervously normal person, they suggest, has the factor for normalness, which is a dominant, from both sides. He is neither insane nor yet "neurotic" nor "neuropathic." Other persons fail to inherit this factor from either side, and, being nulliplex, are liable to be insane. But others are simplex, or impure dominants, and they, while not insane, are liable to be "neurotic," "neurasthenic," "borderland cases," corresponding, of course, to the condition of the hazel eye. A number of pedigrees supporting this view exist, but an important source of fallacy remains, in the form of an unrecognised infection, and all these pedigrees must be revised after that infection has been examined for. Nevertheless, the American theory is probable and suggestive, and may apply to many other degrees of human characteristics. So much as preliminary illustration of Bateson's explanation of Mendel's law.

If we have firmly grasped the great simplification of theory which its author modestly calls the "presence and absence hypothesis," we are ready to tackle the many and important complications which have been unravelled by the breeding experiments of the past decade. Such questions as the differences between the sexes; the distribution of characters, normal and morbid, along with others, such as those of sex; the possible relation between apparently unrelated characters, such as, perhaps, red hair and hasty temper; the nature of the factors in the germ-cells; the possible construction of new forms of vegetable and animal life—all these theoretical and acutely practical questions, with the illimitable vista they open out, are yet before us. Professor Bateson's striking words will encourage the student: "I do not dare to suggest that in magnitude or splendour the field of Genetics may be compared with that now being disclosed to the physicist or the astronomer; for the glory of the celestial is one and the glory of the terrestrial is another. But I will say that for once to a man of ordinary power who cannot venture into those heights beyond, Mendel's clue has shown the way into a realm of Nature which for surprising novelty and adventure is hardly to be excelled."

The First Stage of Genetic Analysis. The symbols we have used, and the arguments which they represent, have already taught us to think in terms of the simple fact that every individual formed by the union of *two* germ-cells is, in a true sense, double, as well as being also, in a still deeper sense, a single individual. Up to a point we see illustrations of this truth, for "we all know that a man may have his father's hair, his mother's colour, his father's voice, his mother's insensibility to music, and so on." But that is only the first stage towards our complete genetic analysis. For in each of such respects, and many more, the individual is in a sense double, because *each* of the two germ-cells, or gametes, which composed him has to be reckoned with as to whether it carried or did not carry the factor in question. Here are the authoritative words of Bateson himself.

"The contribution of each gamete in each respect has thus to be separately brought to account. If we could make a list of all the ingredients that go to form a man, and could set out how he is constituted in respect of each of them, it would not suffice to give one column of values for these ingredients, but we must rule two columns, one for the ovum and one for the spermatozoon, which united in fertilisation to form the man, and in each column we must represent how the gamete was supplied in respect of each of the ingredients in our list."

C. W. SALEEBY

**Advice and Freight Notes. Bills of Lading.
Liability of the Shipowner. Charter Parties.**

SHIPPING GOODS ABROAD

SEEING that the shipping business of the United Kingdom—that is, the imports and exports combined—is so huge, it is not surprising that there should be many other points to be dealt with in addition to those already set forth in the chapters on Imports and Exports. A number of documents have to be made out and various formalities complied with in order that the Customs and other regulations may be observed. It is because of this that in all our ports there are shipping agents who make it their business, for a small commission, reckoned at so much per package, to receive goods being sent abroad by inland manufacturers, and to see that they are put safely on board, all the necessary formalities being properly carried out.

Advising the Shipping Agent. The manufacturer utilising the services of the shipping agent in this way should take care to advise him, some time before despatch, of the approximate number of packages that are likely to be sent, and, if possible, of their measurements. As stock-size packages are often used by a manufacturer, this information is usually available beforehand. It should be sent as early as possible, so that arrangements can be made for reserving space in the vessel. The information should be sent to the local shipping agent, and the agent at the port of shipment should also be advised, in order to avoid any possibility of delay or forgetfulness on the part of the local agent.

The Advice Note. The exporter hands the goods to a railway company or firm of carriers, and then fills up an advice note, which he sends to the shipping agent at the port of shipment. This is headed with the town where the manufacturer's works are situated, and the date, and contains some such note as follows: "Dear Sir,—We send you herewith particulars of six packages which we are forwarding to you by Great Northern Railway, and shall be glad if you will ship these to Bombay by the steamship 'Nizam' in accordance with the instructions given below.—Yours," etc. Then, set out in tabulated form, will be given full particulars of the goods to be shipped, with the marks and numbers of the packages, and the number of cases or bales, the contents, the gross and net weights and the measurements, and the value, together with the name of the ship and the dock or port to which the goods are being sent for shipment. It is essential that all these particulars be set forth very clearly and accurately in the advice note, so that the shipping agent may be able to fill up properly all the Customs documents required for the shipment. In reply, the agent sends a freight note, and the shipment is then completed by the exporter sending a cheque in payment of the freight and other shipping charges.

The Freight Note. The freight note is really a statement sent by the agent to the shipper, showing the amount due for the work done in placing the goods on board ship. The charges include freight, reckoned according to weight or measurement, as the case may be, and primage, which was formerly a gratuity given by the shippers to the captain of the vessel carrying their goods, as a reward for his care and trouble in receiving and looking after the goods while in his charge, but is now simply an additional percentage on the freight, and is supposed to be for the use of ropes, cables, etc., necessary in loading the cargo. The rate of primage differs at the various ports. The freight note contains also the charges for the bill of lading and commission. The bills of lading are usually enclosed with the freight note.

Charging Freight Forward. In some cases, of course, the freight and other shipping expenses are charged forward—that is, to the buyers of the goods instead of to the shippers; and the shipping agent is asked to cover the marine insurance up to a certain amount. In such a case the advice note mentions that the marine insurance is to be charged to the shipper, while the freight and other expenses are to be charged to the firm to whom the goods are addressed. The shipping agent would then send the bills of lading and the freight note to the consignee, and only the account for the insurance to the consignor.

The Mate's Receipt. The shipping agent is sometimes unable to send the bills of lading at once. If the goods have been put on board very hurriedly at the last moment, he will send a mate's receipt, which states that so many packages, with such and such marks, have been received on board the steamship So-and-so, for whatever port the goods have been consigned to. The time and date the goods were received is set forth, and the whole is signed by the mate of the vessel or his clerk. Where the receipt is an absolute one, everything having been in order, it is termed a "clean receipt"; but if there was anything wrong about the consignment—if, for instance, some of the packages were damaged or broken open, or if the number of cases received differed from the number specified in the delivery sheet—then these facts are noted, and the receipt is called a "foul receipt." The mate's receipt is later on exchanged for the bill of lading.

How Freight is Charged. Before going on to describe the bill of lading, something must be said here about freight. While, owing to competition, the steamship companies are not so independent as they once were, and freights are

lower than they were many years ago, the tendency in these days is for the companies to form rings, so as to ensure that the freight shall not go below a certain minimum. In many cases a rebate, consisting of a percentage off the total amount of the freight on all goods shipped by a particular exporter, is allowed if the shipper uses only the lines in the combine. This rebate is usually paid half-yearly. If the shipment is a very large one, the steamship companies will usually quote a specially low rate, provided the rush of general business is not so great as to make them independent of the shipper, and therefore able to keep up the rates rigidly. Of course, where the merchant has so large a shipment that he can fill or almost fill a whole vessel, it will pay him to charter a ship specially for his own purposes. But something will be said in greater detail later about this.

Weight versus Measurement. Freight is charged on either the measurement of the packages or their gross weight, whichever happens to work out best for the shipping company. For most goods the measurement is taken, and forty cubic feet are reckoned as a ton. the freight being charged at so much per ton. If, however, the gross weight is more than the tonnage reckoned by measurement, then the freight is charged on the weight. Thus, if a case measured 40 cu. ft., and weighed 15 cwt., it would be reckoned by measurement and considered as one ton; but if it measured 30 cu. ft., and weighed 40 cwt., it would be reckoned by weight, and charged up as two tons. This may, at first sight, seem unfair to the shipper, and all in favour of the shipping companies, but as a matter of fact, in practice it works out very fairly.

Primage and Other Charges. Primage added to the freight is usually reckoned at 10 per cent., although this is not invariable, for it differs at different ports. The various other incidental charges, such as carriage to the port of shipment, cartage from the station to the dock, and dock dues or harbour expenses, are sometimes charged separately, but more often are lumped together by the agent, who, in this way, is able to secure a little extra profit.

The Bill of Lading. We now come to the bill of lading, which is the most important document in connection with the shipping trade. It is really the contract document in which is set forth the terms on which the goods are being carried by the steamship company to their destination, and it is also the document in which the captain of the ship acknowledges the receipt of the goods upon his vessel. The bill must be signed by the master of the ship himself, or, in his absence from the vessel, by a duly accredited agent. It states the number of packages, with their marks and numbers and their condition. It gives their weights or measurements according to the way the freight is charged, with the rate of the freight, and the total due.

The Wording of the Bill. The wording of the bills of lading of the various shipping companies varies, but in essentials they are all the same. The opening part in which are filled in the particulars, is more or less the same in all, and reads something like this: "Shipped, in apparent good order and well conditioned, by Messrs. James Brown & Sons, and received in good order and condition on the steamship 'Tiflis,' whereof is commander for this voyage Captain J. Robinson, official tonnage 5000, port of register London, now riding at anchor in Victoria Docks, for carriage to Monte Video, and to be delivered subject to the exceptions and conditions set forth below in like good order and condition unto Messrs. Blanco & Co., or to their assigns on freight, primage, and charges for the said goods being paid by the shippers, twenty bales of woollen goods, marked and numbered as in the margin. In witness whereof the master of the said steamship hath affirmed to three bills of lading, all of this tenor and date, one of which bills being accomplished the others to stand void. Dated in London, the 21st day of June, 1914." Then follows the captain's signature.

Explanation of Phrases. Two or three points in this opening paragraph of the bill of lading need elucidation. The phrase "Shipped, in apparent good order and well conditioned," refers to the outside appearance of the packages. The officers of the ship are not expected to open the packages in order to see if the contents are in good order; and in many bills of lading, therefore, it is the custom to provide a safeguard by inserting the words "weight, measure, quality, contents, and value unknown." When merchandise is shipped abroad, the packages do not bear upon them the address of the person to whom they are going, as the consignee may wish to sell the goods without having them unpacked, and is thus able to send them on as received, which would be impossible, or at any rate inconvenient, if they were addressed to the first consignee. It is for this reason that the marks and numbers referred to in the first paragraph of the bill of lading as "in the margin" are placed on the packages. These marks are distinctive, and all the packages in one consignment bear the same mark, and are numbered consecutively, so that they can be easily identified, and there is no difficulty in detecting if one package be missing. Thus, if three cases were going to Messrs. Brown and Jones of Singapore, then each might be marked something like this and have consecutive numbers, as for example, 107, 108, 109.

Most shipping companies, in the body of their bills of lading, insist upon liberty to the steamer, either before or after proceeding towards the port to which the goods are being sent, "to proceed to and stay at any port or places whatsoever, although in a contrary direction or out of or beyond the route to the said port of discharge, once or oftener in any order, backwards or forwards, for loading or discharging cargo or passengers, or for any other purpose whatsoever, and all such ports, places, and sailings shall be deemed included within the intended voyage."

Stipulations of the Bill of Lading. The conditions and exceptions of the bill of lading are in substance much the same for all

shipping companies, and those mentioned here show to what extent the companies protect themselves. The master, owners, or agents of the vessel are not responsible for loss, damage, or injury arising from a number of causes, all carefully set forth as follows: "The Act of God, the King's Enemies, Pirates, Robbers, or Thieves by Land or by Sea, Vermin, Barratry of Masters and Mariners (which means damage done to the ship through wilful neglect or with a deliberate design to commit a fraud upon the insurers), Capture, Seizure, or Embargo, Adverse Claims, Restraints of Princes and Rulers or People, Strikes, Lock-outs, Labour Disturbances, and Trade Disputes, whether partial or general, or anything in furtherance thereof, whether the Owners are parties thereto or not, the Action of Mobs, Effects of Climate, Heat of Holds, Steam, Smoke, Sweating, Insufficiency of Packages in size, strength, or otherwise, Bursting of Packages or consequences arising therefrom, Leakage, Breakage, Pilferage, Chafage (or rubbing), Wastage, Rain, Spray, Rust, Oil, Frost, Thaw, Floods, Decay, Hook-marks (or injury from hooks), Stowage, or contact with or smell or evaporation from any other goods, or damage from Coal and Coal Dust, Drainage of any animals carried in the said ship, or from their stalls, inaccuracies in, obliteration, insufficiency or absence of marks, numbers, or addresses, or description of goods shipped, difference between the marks or contents of the packages and the description thereof in the Bill of Lading, the alleged marks, numbers, or description in the margin notwithstanding, Injury to or soiling of Wrappers or Packages, Loss of Weight, Detention, Delay, Lighterage to or from the vessel, Transhipment, Landing, Jettison (which means the throwing overboard of goods under stress of weather or to prevent foundering), Explosion, Heat, Fire on board or on the Shore, at any time or in any place, nor for Incorrect delivery, Perils or accidents of the Seas, Rivers, and Navigation, Boilers, Machinery or appurtenances, Refrigerating engine or chamber, or any part thereof, Pumps, Pipes of any kind, including consequences of defects therein or damage thereto, collision, stranding, heeling over, upsetting, submerging, or sinking of ship in Harbour, River, or at sea, Admission of Water into vessel by any cause and whether for the purpose of extinguishing the fire or for any other purpose, unseaworthiness of the ship at or after the commencement of the voyage, any act or omission, negligence, default, or error in judgment of the Pilot, Master, Mariners, Engineers, Stevedores, Workmen, or other persons in the service of the Shipowners or their agents, whether on board the said ship or any other ship belonging to or chartered by them, for whose acts they would otherwise be liable." From all this, it will be seen that the shipping companies do their best to cover themselves. Where, owing to the route, there are special or peculiar risks, these are put in, as in the case of the P. & O. line, who, among other things, mention in their bills of lading "Accidents, loss, damage, delay, or detention from any act or default of the Egyptian Government or the Administration of the Suez Canal, or arising out of or consequent upon the employment of the company's vessels in or assistance rendered by them in the performance of his Majesty's Mail Service."

Shipowners' Right to Carry by any Vessel. But these are only a few of the conditions set forth in a bill of lading, being, in fact, all contained in the first clause, whereas in many bills there are thirteen or fourteen clauses. The masters, owners, or agents of the vessel have full liberty to carry the goods by the steamer specified in the bill, or by any other ship or ships, either belonging to the same line or to other persons, and in so doing, without notice to the shippers or consignees, to carry the goods past their port of destination, or land them at intermediate ports, and to tranship, or land and store the goods, either on shore or afloat, and re-ship and forward the same by land or by water, by craft, steam, sail, or barge, whether in tow or otherwise, at the ship's expense but at the merchant's risk, it being understood that all claims for loss or damage consequent upon delay or detention of the goods from the foregoing or any other causes are excluded.

Where the Goods are to be Stowed. According to the bill of lading, the goods are to be stowed under the main deck or between the main deck and upper deck, or in the poop or in the bridge-house or deck-houses, or in peaks, or on deck, at the master's option and the shipper's risk. Should it be found when the cargo is discharged that the goods have been landed without marks, or having marks differing from the bill of lading, the same is to be apportioned by the master porter or receiver of cargo to the different lots, and the consignee's shall conform to such allotment. Where bulk goods, or goods without marks, or with the same marks, are shipped to more than one consignee, the consignees shall jointly and severally bear any expense and loss in dividing the parcel into *pro rata* quantities, and any deficit shall fall upon them in equal proportions as the agent of the vessel may decide.

Conditions of Discharging the Goods. The goods are to be discharged from the vessel as soon as she is ready to unload at the wharf, or into hired lighters, and to be landed by the master or agents, but at the expense and risk of the owners of the goods. The ship may, quite irrespective of weather, discharge continuously, Sundays and holidays included, and should the master or agents require discharge to be made beyond the usual Custom House hours, the consignees are bound, if so required, to sign immediately an application for this purpose. In case of quarantine or other sanitary regulations, the goods may be discharged into quarantine depot, or other vessel, as required for the ship's despatch, or should this be impracticable, or the ship not be admitted, the master may proceed on his voyage and land the goods at the nearest safe port, in his opinion, at the risk and expense of the owners of the goods, or retain them on board till the ship returns. Quarantine expenses upon goods, of whatever nature or kind, have to be

borne by the owners of the goods. In case of the blockade or interdict of the port of discharge, or if the entering of or discharging in the port is considered by the master in his absolute discretion unsafe by reason of quarantine, war, or disturbance, whether existing or only anticipated, or from any other cause, the master may land the goods at any other port which he may consider safe, at the expense and risk of the owners of the goods. The ship's responsibility ceases when the goods are thus discharged under quarantine, or landed at another safe port.

The Payment of the Freight. On most bills of lading it is distinctly stated that the freight is to be paid by the shippers in full, without abatement or discount, in exchange for the bill of lading, whether the ship is lost or not lost. The full freight is due on damaged or unsound goods. The owners or agents of the ship have a lien on the goods, not only for the freight or charges thereon, but for all previously unsatisfied freights and charges due to them by the consignee, and in the event of any accident requiring a contribution to be made by the consignee in general average, the consignee shall, before receiving the delivery order for the goods, be bound to sign the average bond, and pay to the master, owners, or agents of the vessel such reasonable deposit towards the average expenses as they may require, and they shall have a lien on the goods for the payment.

All fines, expenses, losses, or damage which the shipowners or their agents or servants or the ship or cargo may incur on account of the incorrect or insufficient marking of the packages or description of their contents, or the nature of such contents, or on account of the absence of any particulars required by the authorities at the port of loading or discharge, or the failure to provide any particular document, or to meet any other requirements of the authorities, must be paid by the shipper or consignee as required, and the owners or agents of the vessel have a lien on the goods for this payment Any such lien may be made available by sale or otherwise. The masters, owners, or agents of the ship are not responsible for any loss arising from the consequences of the Customs law of foreign countries. The freight on live-stock is payable on the number of animals shipped, irrespective of the number or condition of those landed, and the master and owners, etc., of the ship are not responsible for the death or injury of the stock, however occasioned, all live-stock being carried at the shippers' risk absolutely. It is distinctly specified that no damage, injury, or loss arising to live-stock is recoverable in general average, but must be borne by the owners of such stock. All the expenses of landing live-stock must be borne by the shippers or their consignees.

Liability of the Shipowners. The bill of lading carefully specifies the restrictions on the shipowner's liability, even where, amid all the exceptions and stipulations, he has a liability. He is not liable for any damage to goods or for any claim notice of which is not given before the removal of the goods from the vessel. He is not accountable for costly merchandise—jewellery, rare china, furs, laces, and so on—beyond the value of two pounds sterling per cubic foot for any one package, or relatively for any proportion thereof, nor in any case for any amount beyond the invoice price of the goods, unless shipment be made upon a special order containing a full declaration of the value, and the bills of lading are signed in accordance therewith, and extra freight paid. Any claim which an owner of goods, whose ownership is carried on through the bill of lading, wishes to prosecute can only be made against the party in whose possession the goods were when the event occurred on which the claim is based; that is, a ship conveying part only of any lot of goods for which a through bill of lading was granted is not responsible for the delivery of the remainder of such lot. Through goods are subject to all the conditions of the receipts given by each company by whose line they pass to their destination. Any claims for loss by damage or short delivery or otherwise arising out of the bill of lading can, in the option of the shipowners, be settled direct with the owners in England according to English law, to the exclusion of proceedings in the courts of any other country.

Goods Liable to Confiscation. Any goods of an inflammable, explosive, or otherwise dangerous character, shipped without permission and without full disclosure of their nature, may be seized and confiscated or destroyed by the shipowner, at any time before delivery, without any compensation to the shipper or consignee, and the shipper is responsible for all damage, loss, or expense that may be sustained by the shipowners in consequence of such shipment.

Other Conditions. Still other conditions are contained in a bill of lading, as for instance that the ship has liberty to sail with or without pilots, to tow and assist other vessels in all situations, and to carry goods of all kinds, dangerous or otherwise. It is also usually declared that the shipowner is not liable for any loss, detriment, or damage to any goods which are capable of being covered by insurance, and that in case any part of the goods cannot be found for delivery during the vessel's stay at the port of discharge, they are to be sent back at the ship's expense at the first opportunity when found; the vessel not to be held liable for any loss arising from such over-carriage.

Of course, as already stated, bills of lading vary a good deal, and, while some of them are fairly simple, others are formidable documents with many long clauses printed in small type. The conditions and stipulations set forth above, however, are culled from a number of bills, and are fairly general. It will be seen that the responsibility of the shipowner is very restricted. Sailing-ships usually give much simpler bills of lading than steamships.

Stamping and Despatching the Bills of Lading. As already indicated, the bills of lading are made out in triplicate, and each copy must, to be effective, be stamped with a sixpenny stamp before the document is signed. If the bill is signed before it is stamped, the

person who executes it is liable to a fine of fifty pounds. The merchant sends one copy of the bill of lading by mail to the consignee, another he sends by the steamer addressed to the consignee, so that if the vessel arrives before the mail, as occasionally happens, there may be no unnecessary delay in obtaining the goods; the third copy the merchant retains for reference. In some cases the second bill, instead of being sent by the ship, is forwarded by a succeeding mail, in case the first bill miscarries. Sometimes these three copies have printed on them the words Original, Duplicate, Triplicate, as the case may be. Another copy, this time an unstamped one, is handed to the master of the ship by the shipping agent, with the other ship's papers, and is called the "Captain's Copy." Sometimes, in order to save the trifling stamp duty, the exporter's copy is not stamped, and in such a case it must not be signed, or the penalty will be incurred.

When Liability Begins. Many legal points arise in connection with a bill of lading. It is important, for instance, that anyone engaged in the shipping business should know when the liability on a bill of lading actually begins. It has been upheld by a legal decision that the liability of the master of a ship who has signed a bill of lading on behalf of the owners of the vessel begins as soon as there has been delivery to the shipowner's servants, even though the goods may not have been delivered on board. The bill remains in force until the shipowner has fulfilled his engagement.

Delay at Sea. It has been held by the courts that the principles that govern the recovery of damages for delay on land cannot be applied to conveyance by sea. The decision is an important one to shippers. "If goods," said the judge, "are sent by a carrier to be sold at a particular market; if, for instance, beasts are sent by railway to be sold at Smithfield, or fish is sent to be sold at Billingsgate, and by reason of delay on the part of the carrier they have not arrived in time for the market, no doubt damage for the loss of market may be recovered. So if goods are sent for the purpose of being sold in a particular season when they are sold at a higher price than they are at other times, and if by reason of a breach of contract they do not arrive in time, damages for loss of market may be recovered. Or if it is known to both parties that the goods will sell at a better price if they arrive at one time than if they arrive at a later time, that may be a ground for giving damages for their arriving too late and selling for a lower sum. The difference between cases of that kind and cases of the carriage of goods for a long distance by sea seems to be very obvious. In order that damages might be recovered, we must come to two conclusions—first, that it was reasonably certain that the goods would not be sold until they did arrive; and secondly, that it was reasonably certain they would be sold immediately after their arrival, and that that was known to the carrier when the bills of lading were signed. It appears to me that nothing could be more uncertain than either of these two assumptions in this case. Goods imported by sea may be, and are, every day sold while at sea. . . . . In this particular case the plaintiff did not sell the goods when they arrived, for he sold them some months afterwards, when a further fall had taken place in the market. How can we tell that he would not have done exactly the same thing if the goods had arrived in time? Therefore, it seems to me that to give these damages would be to give speculative damages—to give damages when we cannot be absolutely certain that the plaintiff would not have suffered just as much if the goods had arrived in time."

A Bill of Lading a Negotiable Document. A bill of lading is negotiable, and any one copy that has been honestly come by will give a title to the goods. For this reason, banks which advance money against a bill of lading always take care to secure possession of all the copies, or, as it is technically called, a "full set." The Bill of Lading Act, 1855, defines the title of the holder of a bill. "Every consignee of goods named in a bill of lading," says the Act, "and every endorsee of a bill of lading to whom the property in the goods therein mentioned shall pass upon or by reason of such consignment or endorsement, shall have transferred to and vested in him all rights of suit, and be subject to the same liabilities in respect of such goods as if the contract contained in the bill of lading had been made with himself. Nothing herein contained shall prejudice or affect any right of stoppage in transitu, or any right to claim freight against the original shipper or owner, or any liability of the consignee or endorsee by reason or in consequence of his being such consignee or endorsee, or of his receipt of the goods by reason or in consequence of such consignment or endorsement.

"Every bill of lading," continues the Act, "in the hands of a consignee or endorsee for valuable consideration, representing goods to have been shipped on board a vessel, shall be conclusive evidence of such shipment as against the master or other person signing the same, notwithstanding that such goods or some part thereof may not have been so shipped, unless such holder of the bill of lading shall have had actual notice at the time of receiving the same that the goods had not been in fact laden on board: Provided that the master or other person so signing may exonerate himself in respect of such misrepresentation by showing that it was caused without any default on his part, and wholly by the fraud of the shipper, or of the holder, or some person under whom the holder claims."

Letter of Indemnity. As a shipowner is responsible for any damage to the goods he is carrying, other than the damage against which he is protected in the conditions set forth in his bill of lading, it is the practice to note in the mate's receipt, and sometimes in the bill of lading also, any damage discovered in the packages when they were put on board. A bill so endorsed is said to be a foul bill of lading, and bankers look with suspicion upon such documents, because a claim is almost certain to be made when the goods arrive. It is the custom,

therefore, for the shipper to give what is known as a letter of indemnity to the agents or master of the ship, so as to secure a clean bill of lading. This is worded somewhat in this way: "To the captain of the s.s. 'Elim,' from London to New York. Dear Sir,—In consideration of your signing clean bills of lading for [here follow the name and description of the goods, with the marks, etc.] shipped by us on your steamship, the mate's receipt for which states two bales broken, we hereby undertake to indemnify you against any claims that may be made on account thereof on the arrival of the steamship at New York." This letter is generally attached to the captain's copy of the bill of lading; and if, when the vessel arrives, a claim is made and settled on account of the damage, it is afterwards recovered from the shippers.

A Charter Party. When a merchant has so many goods to ship to a certain port or part of the world that he can fill a whole vessel, he hires or charters a ship, and the document which contains the terms of the agreement between him and the shipowner is called a charter party. All the conditions of the contract are fully set forth, with the obligations of both the merchant and the shipowner. As in the case of bills of lading, the wording varies according to the shipowner concerned, but the document usually reads very much like this.

"It is this day mutually agreed between William Jones and Sons, owners of the steamship called the 'Aurora,' of the measurement of 4500 tons net register, classed A1 at Lloyd's or equal thereto, now at anchor at this port, and Messrs. James Robinson and Company of London, merchants and charterers. That the said steamer, being tight, staunch, and strong, and in every way fitted for the voyage, shall with all convenient speed receive and take on board a full and complete cargo, consisting of woollen goods in 2300 bales, and being so loaded shall proceed as ordered on signing bill of lading to one safe port on the Continent between Havre and Hamburg, both inclusive, or as near thereunto as she may safely get, and deliver the same on being paid freight at the rate of forty shillings per ton, being in full of all port charges and pilotages as customary."

Conditions of a Charter Party. The conditions of the charter party are then set forth usually as a series of numbered clauses. "The freight to be paid on unloading and right delivery of the cargo, in cash at the current rate of exchange. As much cash as the master may require for the ship's ordinary disbursements at the port of loading, not exceeding £150, to be advanced, if required, subject to 3 per cent. for interest and insurance. Fourteen working days, Sundays and holidays excepted, are to be allowed the said charterer for loading, and ten days on demurrage, over and above the said laying days at fourpence per net register ton per day. Lay days to count twenty-four hours from the captain's written notice of readiness for loading. Charterers to have the option of loading on Sundays and holidays, such days to count as lay days for the time actually occupied. The cargo is to be brought to and taken from alongside the ship at the charterer's risk and expense. The captain is to sign the bills of lading as presented, if in accordance with the mate's receipts, and at any rate of freight, without prejudice or reference to this charter party, if not at variance therewith, the owners having a lien on the cargo for freight, dead freight, and demurrage. Should the total freight shown by bills of lading amount to less than the freight stipulated by this charter, the difference is to be paid to the captain before sailing, and should the freight as shown by the bills of lading amount to more than the freight stipulated by this charter, the difference is to be paid before starting to the charterers by captain's draft on the owners, payable forty-eight hours after arriving at the discharging port."

There is also a clause setting forth as in the bill of lading the various causes, such as "act of God, pirates, thieves, etc.," for the damage resulting from which the shipowners are not liable.

There is no specified legal phraseology for a charter party, but in substance they are as stated above. In the case of voyage charters, the ship is hired for a certain specified voyage; in time charters it is for a fixed time.

Points about a Charter Party. The charterer is not, of course, obliged to fill the ship with his own goods. He may sublet a part of the vessel, or he may fill up by undertaking to carry the goods of other merchants at any rate he likes to fix, quite independent of the shipping company. The phrase "tight, staunch, and in every way fitted for the voyage" is known as the warranty, and implies that the vessel is seaworthy and fully capable to take the voyage contemplated. Very often the port to which the ship is to take her cargo is not named in the charter party, but, as in the case given above, the words "one safe port on the Continent between Havre and Hamburg, both inclusive," are used. The exact name of the destination is usually filled in before the vessel sets out. When a vessel is chartered at a foreign port, it is usually done through a shipbroker, who signs the charter party as agent for the shipowner.

Freight of Charter Parties. When a vessel is chartered, the freight is usually reckoned on a basis of so much per ton of forty or fifty feet, although for some cargoes it is reckoned at per ton weight. Occasionally a lump sum is paid. If for some reason the chartered vessel is unable to get all the cargo it is capable of carrying, the freight has to be paid on that which is missing, just as though it had been shipped, and this is called dead freight. In a time charter the freight is sometimes agreed to in one lump sum, and at other times it is reckoned at so much per ton per day during the period the ship is chartered.

Lay Days. The lay days mentioned in the charter are the days allowed for loading and unloading, and begin as soon as the ship has been given permission to load or discharge. They are sometimes described in the charter party as running days, and sometimes simply as working days, but there is a difference which it is important that the charterer should note.

Running days are consecutive days without a break of any kind, but working days are those devoted to actual work at the port where the ship is loading, and do not include Sundays and holidays. Charter parties usually stipulate that there shall be an allowance of so many days on demurrage, over and above the number of lay days, on payment of so many pence per register ton per day. A steamer's demurrage is usually reckoned at £20 or £25 per day. It is sometimes agreed that despatch money shall be paid; that is, that for every day saved out of the lay days in loading the charterer shall receive a certain sum, usually reckoned at £10 or £15 per day if the vessel is a steamer, and if she is a small sailing-vessel at much less, of course.

Bottomry and Respondentia Bonds. Sometimes the master of a vessel during a voyage is compelled, owing to stress of weather or other causes, to put into a port for repairs, and it becomes necessary for him to raise money to pay for these. In order to do so, he may draw and sell a draft on his owners, which is the usual method, but sometimes the master finds himself unable to sell his bill. Two courses then lie open to him. One is to raise money on the ship itself, or on the ship and its cargo; and the other is by selling some of the cargo, which, in the circumstances, he has a legal right to do. In the former case he executes what is known as a bottomry bond if he pledges only the ship; but if he pledges also the cargo, then the document is called a respondentia bond. The bond is really a mortgage on the ship, or the ship and its cargo, which is given as security for the repayment of money advanced for the repairs, etc. The term "bottomry" is used because the captain pledges as security the keel or bottom of his vessel, as representing the whole ship.

Certificates of Origin. For certain countries a document known as a certificate of origin is required with the goods shipped, this being an authorised indication of the country from which the goods have come. The point about the certificate of origin is that it helps the British manufacturer by enabling his goods to enter a country at a smaller Customs duty than that levied on the goods of another country. In the case of some of our Colonies, such as Canada, Australia, and so on, there is a discrimination made in favour of British goods, which pay a lower duty than those of foreign countries, the certificate of origin being the testimony that the goods have really come from Britain. The certificate of origin also works in favour of British goods when two tariff countries are carrying on a tariff war with one another. They increase the Custom dues on one another's goods, and the certificate of origin, by showing that the merchandise is British, secures a lower duty than the country engaged in the tariff war would have to pay. These certificates of origin have to follow certain recognised forms, which are different for the different countries, and while the forms may be obtained from the Agents-General of the Colonies, the Parliamentary law stationers, and others, large firms usually print them themselves on the backs of their invoices. The certificate for Canada, for instance, must be signed by the manager or other responsible official of the firm; and after a declaration that he is authorised by his firm to act, the manager proceeds to testify that all the articles included in the invoice are bona fide the produce or manufacture of Great Britain; that the said invoice contains a true and full statement showing the price actually paid for the said goods, the actual quantity thereof, and all charges thereon; that the said invoice also exhibits the fair market value of the said goods, and that no different invoice of the goods mentioned has been or will be furnished to anyone; and that no arrangement or understanding affecting the purchase price of the said goods has been or will be made or entered into between the exporter and purchaser, or by anyone else on behalf of them, either by way of discount, rebate, salary, or compensation.

For Russia, a certificate of origin may be made out in English or French, and must bear the signature of the secretary of a Chamber of Commerce. For Spain the document must be in French or Spanish, and the Chamber of Commerce secretary's signature must be viséd by the Spanish consul of the district from which the goods are exported.

The Ship's Papers. Every British ship carries what are known as ship's papers, a series of documents usually nine or ten in number. The certificate of registry is a paper granted by the registrar of the port where the vessel has been registered, and is the legal proof of her nationality. It specifies her name, description, and tonnage, the name of her master, and the name of her owner. The ship's log is the book containing a daily record of the vessel's progress, the winds and weather encountered, and so on. The ship's articles are the agreements which the seamen have signed, and they state each man's rank, wages, and term of engagement, and also the food to be provided. The crew-list or muster-roll is a list of all the persons on board the vessel. The bill of health is very important; it is a certificate granted by the consul at the port which the vessel has left, stating whether any infectious disease existed at that place at the time of sailing. Where there was no such disease the bill of health is said to be "clean." If there was any infectious disease, then the bill is described as "foul."

The manifest is a description of the ship's cargo, with the marks and numbers, contents, and value of each package. It is usually signed by the master or agent of the steamship company. The ship's papers also very often include the builder's certificate and the bill of sale, the document given by the seller to the buyer when the vessel changed owners. They also include the charter party.

These chapters on imports, exports, and the shipping of goods will give a general idea of the principles of shipping business, but the details must be learned in actual practice in an office where the export or import business is being carried on.

CHARLES RAY

Rays of Light and their Characteristics. Magnetism and Light. Radiation Pressure. The Weight of Light on the Earth.

LIGHT RAYS AND LIGHT PRESSURE

We already know that just as there are rays beyond the violet, so there are rays below the red. These, indeed, are none other than the rays of radiant heat.

The Rays of Radiant Heat. When sunlight is spread out into a spectrum, these rays also are sorted out into their places. If we place a highly sensitive thermometer in various parts of the spectrum, in succession, we can precisely ascertain their heating power. We find that the greatest heating power is exercised by a part of the spectrum considerably below the red, and that from this point onward the heating power steadily diminishes, until at the violet end of the spectrum it has practically vanished altogether.

We clearly understand, of course, that these infra-red rays are related to the red rays, just as a C on the piano is related to a D or an E above it. They are in every respect as real as the visible rays. The essential difference between them, from our point of view, is merely that our retinæ are so constructed that we can see the one kind but are blind to the other. In proof of this, we may note that, just as there are Fraunhofer lines in the visible spectrum, so there are absolutely identical lines in the infra-red part of the spectrum—lines or gaps where there is no radiation at all, and the explanation of which is identical with that of the gaps the presence of which can be detected without difficulty by direct vision.

Light and Magnetism. Further aspects of spectroscopy are discussed in considering the chemistry of the stars [see CHEMISTRY]. Meanwhile, however, we must briefly consider a special aspect of spectroscopy which depends upon the relations between light and magnetism. In discussing this subject, there is no choice but to use certain phrases the meaning of which cannot positively be understood until magnetism itself has been studied, but we shall reduce their employment to the smallest possible limits.

The relations between magnetism and light are of fundamental importance, and in considering the most important of them we cannot do better than quote freely from the words of Professor Sir J. J. Thomson. He points out that "the first relation between magnetism and light was discovered by Faraday, who proved that the plane of polarisation of a ray of light was rotated when the ray travelled through certain substances parallel to the lines of magnetic force. This power of rotating the plane of polarisation in a magnetic field [see page 493] has been shown to be possessed by all refracting substances, whether they are in the solid, liquid, or gaseous state."

It was natural that, having made this great discovery, Faraday should seek to see whether a magnetic field influenced the nature of the light emitted by any luminous body, but Faraday's apparatus was not adequate to bring him success. A great advance was made by Professor Zeeman, of the University of Amsterdam. He found that spectral lines characteristic of lithium and of sodium were decidedly broadened if the flames containing salts of these substances were placed between the poles of a powerful electromagnet.

"Rays of Light in a Magnetic Field." Zeeman found that "in a strong magnetic field, when the lines of force are parallel to the direction of propagation of the light, the line (characteristic of cadmium) is split up into a doublet, the constituents of which are on opposite sides of the undisturbed position of the line, and that the light in the constituents of this doublet is circularly polarised, the rotation in the two lines being in opposite directions." On the other hand: "When the magnetic force is at right angles to the direction of propagation of the light, the line is resolved into a triplet, of which the middle line occupies the same position as the undisturbed line; all the constituents of this triplet are plane-polarised, the plane of polarisation of the middle line being at right angles to the magnetic force, while the outside lines are polarised in a plane parallel to the lines of magnetic force."

It is not possible here to go into the mathematics of this subject. Professor Lorentz has gone very far to explain the Zeeman effect, and his explanation is entirely in accord with the modern view of the structure of matter [see CHEMISTRY]. The interpretation of Zeeman's observation leads us to believe, first of all, that the bodies which produce the luminous vibrations which the spectroscope analyses are negatively electrified. Secondly, the properties of such bodies closely correspond to those of the negatively electrified particles which constitute what are still called the *cathode rays*, and which we now know as *electrons*. "Thus we infer," says Sir Joseph Thomson, "that the cathode particles are found in bodies even where not subject to the action of intense electrical fields, and are, in fact, an ordinary constituent of the molecule [the atom]."

Light under Magnetic Force. But the Zeeman effect will teach us far more than this, though such a confirmation of the corpuscular theory of matter is obviously of the greatest value. It is found that magnetic fields influence light in a far more complex fashion than that hitherto described. Spectral lines are sometimes split up into sixes and nines as well as threes. This indicates that the lines in question must be due to the vibration within the

atom of systems consisting of more electrons than one. This, of course, entirely coincides with the doctrines which we have advanced in the course on CHEMISTRY, where it is shown that within the larger atoms there are sub-atoms, or systems of corpuscles, such as those which give rise to the helium atom when the radium atom disintegrates. Several years ago Sir Joseph Thomson said: "Thus the behaviour of the spectrum in a magnetic field promises to throw great light on the nature of radiation, and perhaps on the constitution of the elements." And about the same time Dr. Knott said: "The general explanation of the phenomenon follows at once from Maxwell's electromagnetic theory of light, taken in conjunction with the obvious hypothesis that, in the molecules whose vibrations are the source of the radiation, there are electrical vibrations which will respond to a magnetic force brought to bear upon them."

Spectral Lines and the Theory of Matter. Sir Joseph Thomson predicted that the recent discoveries as to the relations between magnetism and light would help us to understand the constitution of the elements. This prediction has been abundantly verified. Ten years after his original discovery, Professor Zeeman was asked to show some of his famous experiments, and offer the most recent interpretation of them, before the Royal Institution. He then pointed out certain facts which we may here quote.

"The study of the spectral lines," said Professor Zeeman, "affords a most cogent support to the electronic theory of matter. Furthermore, it has long been known that in the spectra of many metals there occur certain series of related lines which show a correspondence in the various groups of metals. The lines which belong to different series show the difference between them by the fact that they always behave differently under the influence of magnetism, but the fundamental relation between lines of one series, occurring again and again in related elements, is shown by the fact that these lines behave similarly to one another under the influence of magnetism. We have already seen that some lines are separated into triplets, some into sextets, or sixes, and some into nonets, or nines. Now, it is the fact that, in a group of elements, corresponding series of spectral lines show the same degree of resolution, whether into threes, sixes, or nines." In a word, the more intimately we study the Zeeman effect, the further proof do we find of the relation between the elements, and the more nearly do we come to understand in what that relation consists. In short, we may say that the magnetisation of the spectral lines affords one of our very best clues to the inner structure of the atom.

The Zeeman Effect Summarised. The Zeeman effect, in the words of the discoverer himself, may thus be briefly summarised: Certain spectral lines are divided into three in a magnetic field when the lines of magnetic force are at right angles to the direction of propagation of the light. Of these three, the middle component is plane-polarised in one direction, and the two outer components in a different direction. If the lines of force are parallel to the direction of propagation of the light, similar lines are split up into only two components, which are circularly polarised in opposite directions to each other. Hence, it may be argued that, in a gas which is emitting light, the ethereal vibrations arise from negatively electrified corpuscles, the size of which corresponds to that suggested by the study of the cathode rays.

All the Facts Consistent. As we have seen, corresponding series of spectral lines in different elements—elements forming groups in Mendeléef's table of the Periodic Law—show the same type of resolution of the lines constituting the series, and show the same amount of separation of them. Hence it is inferred—and this is most important—that all the lines constituting a series of spectral lines are produced by one oscillating or rotating system of electrons within the atom, and therefore that the number of series of lines in the spectrum of any "element" indicates the number of oscillating or rotating systems contained in the atom in question; and, lastly, that in a group of related elements the oscillating systems giving rise to corresponding series of spectral lines are identical.

It is of some interest to notice that the amount of separation (due to a magnetic field) of the components of a spectral line is proportionate, as might be expected, to the strength of the magnetic field. This fact, curiously enough, affords a service for the student of magnetism. The most accurate means, and by far the most delicate, of measuring the strength of a magnetic field is to be found in measuring the effect of that field in resolving the spectroscopic lines in the light of some element which has been made luminous for the purpose.

Light as a Carrier of Momentum. When we discussed gravitation and the ether, we made some reference, apparently out of place, to the pressure of light. It was pointed out that this pressure exercised by light against any surface upon which it falls is really no more than an instance of a still more general phenomenon called *radiation pressure*. We observed that light must exercise a pressure if it be of the nature which Clerk-Maxwell demonstrated. It was further noticed that the figures for radiation pressure which Clerk-Maxwell arrived at, *a priori*, have been demonstrated to be practically correct in consequence of the *a posteriori* or experimental demonstration of radiation pressure by Lebedew and by Professors Nichols and Hull [see page 742].

The reason why we had to discuss radiation pressure in that place was that it is a universal or practically a universal force which, in its measure, is opposed to gravitation, because it acts in precisely the opposite direction. We commented upon the fact that radiation pressure compels us to modify our statements both of Newton's first law of motion and of his law of gravitation. Here we must make some brief further reference to the subject.

Radiation Pressure and a Moving Body. We do so, in the first place, because it is properly a part of the subject of light, or, rather, of radiation in general, and also because the work of Professor Poynting, to which we alluded on page 743, has since been discussed by himself at the Royal Institution.

What is probably the most important contribution of Professor Poynting to the subject is the observation that a moving body, whether small or great, which is emitting light—or any other form of radiant energy—tends to crowd upon the waves in front of it, while those behind it tend to be thinned out. The consequence is that the radiation pressure is greater in front of the body than behind it, and constantly acts as a break upon its motion.

Direction of Light and Sound Waves. Now, this case is, after all, only the latest illustration of a theory which goes by the name of *Döppler's Principle*, and plays an important part in many branches of physics. In describing it we cannot do better than quote the authoritative words of Professor Tait. The reader will see from them how this principle is applicable to waves of many different kinds:

"When a steamer is moving in a direction perpendicular to the crests of the waves, she will encounter more of them in a given time if her course is towards them than if she were at rest; while, if she be moving in the same direction as the waves, fewer of them will overtake her in a given time than if she were at rest. The same thing is true of sound-waves. When an express train passes a level crossing at full speed, the pitch of the steam-whistle is higher during the approach to and lower during the recess from the listener at the gate than it would be if the engine were at rest. The successive sound-pulses are emitted at the same intervals as before, but from points successively nearer to or farther from the listener Hence, more or fewer reach his ear in a given time. The principle is precisely the same as that of Römer's observation of the frequency of eclipse of Jupiter's satellites. Th number of light-waves which reach the eye per second is increased if the source is approaching, and diminished if it be receding."

Application of the Principle. Döppler's Principle is usually described under Acoustics, and the usual acoustical illustration has been quoted above, but we have deferred its discussion until this place because it is of far greater importance in relation to light than it is in relation to sound. One of the earliest applications of the principle in the realm of light was made, as we have seen, by the late Sir William Huggins, who was enabled by its means to solve a problem which Comte, for instance, had declared to be necessarily impossible of solution throughout all time; namely, the problem of ascertaining the motion of the fixed stars to or from the earth, or our motion relatively to them—in the line of sight. This problem might indeed appear insoluble, but Huggins was able to ascertain, by the application of Döppler's Principle, the movements of stars which may be moving directly towards us or from us, and the light of which is thus constantly affected in wave length and frequency.

Reflection and Recoil of Light. Let us now return to radiation pressure, and consider a few of its consequences and one or two of the facts which it may more or less certainly explain. From this point of view we have to consider light as a momentum carrier. Now, there are certain fundamental dynamical laws which have their application in this sphere also. We believe, for instance, that action and reaction are equal and opposite. If, then, when we fire a rifle, it kicks, there ought to be a similar back-push or recoil when a radiant body fires off, so to speak, a train of light-waves. The physicist knows, indeed, that this must be so. It is therefore extremely interesting to observe that, when Professors Nichols and Hull made their now celebrated experiments, they obtained just double the result in respect of pressure when the waves of light with which they experimented were reflected. In other words, these waves of light first of all exercised a pressure when they struck the surface, and then gave it a kick as they were reflected from it.

75,000 Tons of Light. Professor Poynting has also studied the influences which light pressure due to radiation from the sun—or, to be more accurate, the whole radiation pressure from the sun—must ever be exercising upon the earth, with the consequence of tending to arrest its onward motion. This amounts to what at first sight would appear to be a formidable figure, the equivalent of the weight of 75,000 tons. But that this resistance to the earth's movement is trivial, and can have marked consequences only in the remotest future, will be evident if we consider that this push of the sun must be pitted against his gravitational pull, which is millions of times greater. Various conclusions of importance follow from the fact that, whereas the force of gravitation varies as the mass of a body, the force of radiation pressure varies as its surface.

Only in the case of very minute bodies, whose surface is very large in proportion to their mass, is light pressure stronger than the pull of gravity. In the case, for instance, of electrons, which are practically all surface, light pressure will be stronger than gravity; and it is believed that electrons emitted from the glowing carbon of the photosphere of the sun are driven some ninety-three million miles across space from the sun to the earth. The electrons are charged with negative electricity, the sun with positive electricity, so that light pressure has to contend against both the gravitational and electrical pull of the sun, but there is no doubt that in the case of such small bodies the light pressure must prevail. When the sun blazes up and the sunspots enlarge, then light pressure becomes correspondingly more potent, and the electrons are hurled most vigorously across space, but at all times probably they are driven along by light pressure.

C. W. SALEEBY

Various Forms and Qualities of Bricks. Varieties of Brickwork. Composition and Mixing of Mortars. Gauged Work.

BRICKLAYING MATERIALS

The manufacture of bricks has been described, but it must be understood that the qualities of brick produced by burning show very great variations, depending largely not only on the nature of the earth from which the brick is made, but also on the manner of moulding and burning them. As a rule, bricks burnt in a clamp show greater differences between the best and worst brick produced than do those burnt in a kiln.

Bricks moulded in a plastic state are more liable to damage after moulding than those moulded dry. The manufacture of the latter requires very powerful machinery, and such bricks are, as a rule, denser, heavier, stronger, and have truer and more uniform edges than those moulded when plastic; they also exhibit a much smaller range in quality and colour.

Malm Bricks. *Malm* bricks burnt in a clamp will result in bricks practically perfect in shape and of an even texture and colour. Such are known as *cutters*. They stand at the top of the scale of quality, and are used for *rubbed and gauged work* [20 and 22]. The next quality is known as *seconds;* they are suitable for the best facing work. *Shippers* are bricks well burnt and hard, but not of perfect shape. They derive their name from having been largely exported in ships as ballast.

Stocks. *Stocks* are also sound and hard, but inferior in form; the majority of bricks in a clamp are of this quality, and are in common use for all ordinary work. Where the outer face of brickwork is required to present a particularly good appearance, free from any great irregularities in colour, the bricks used to form the surface should be picked out from the general mass for evenness of colour and good form, or seconds may be employed for very good face work. All the above classes of bricks, some of which have further subdivisions, are sound and reliable, and are classed according to the regularity of their form and evenness of colour when burnt. They are available for all classes of ordinary building and for either external or internal walls. The prevailing colour is a bright, rich yellow.

Inferior Bricks. The remaining bricks to be described are of a distinctly inferior quality, and their use is restricted to internal walls in inferior work. *Grizzles* are bricks to which air has had access during burning, and are of a greyish colour. *Place bricks* are bricks which are not thoroughly burnt and the surface of which is not vitrified; they are porous, weak, and usually of a pinkish colour. *Chuffs* are bricks that have been acted upon by rain during burning, or have not been efficiently dried; they are soft, and liable to disintegrate, and their employment should be prohibited. *Burrs* are masses of brick which have become fused together during burning; they are found generally near the live holes, where the heat of the clamp is excessive; they are unsuited for ordinary building operations, but are employed in rockeries, or they may be broken up for use in concrete.

Machine-moulded Bricks. The majority of machine-moulded bricks are burnt in kilns, and the quality of bricks produced at each burning is much more nearly uniform than in the case of clamps; but there are very many varieties in this class of bricks produced, due in a large measure to the chemical composition of the clays of which they are composed, and to variations in manufacturing processes. The local varieties are very numerous. Some of the bricks in most general use are the following.

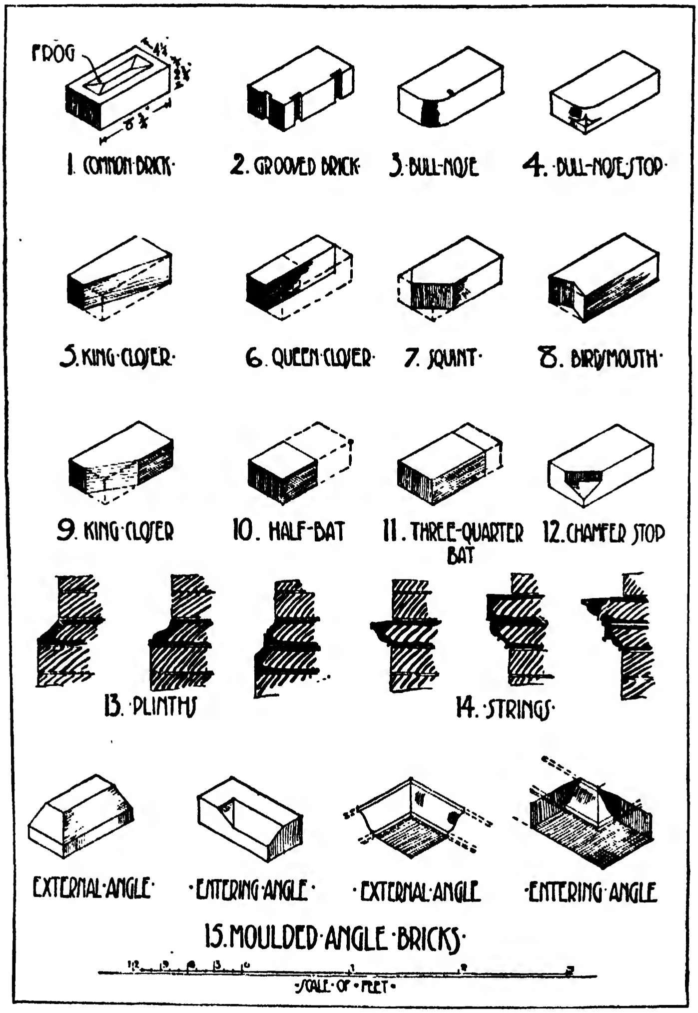
Gault bricks are burnt from the Gault clays in kilns; the best are hard and white, and are usually perforated with circular holes, running vertically through the brick with a view to reducing their weight.

Suffolk bricks are a variety of Gault brick of a very pale yellow colour, and are known as white bricks; they are dense and heavy, and expensive, and are often used for facings.

Fareham bricks are of a bright red colour varying in tone, and are much used as a facing brick, and the best qualities of them for rubbers.

Flettons are bricks made in the Midlands. They are very heavy, dense, and true to form, and work constructed with them will carry heavy loads. They are not of a very good colour, and the surface of the brick is smooth. For walls that are to be plastered these bricks are sometimes moulded with dovetailed grooves [2] to give a better key for the plaster than the smooth brick surface affords. For internal walls left unplastered they offer a very true and even surface for the application of distemper or whitewash; they are sometimes marked with bands nearly black in colour, due to variation in burning.

Staffordshire Bricks. *Staffordshire* bricks are made from a very dense clay; they are extremely hard, dense, almost non-porous, and of a very dark blue colour, verging sometimes on black. They will carry very great loads, and are used for brick piers carrying concentrated weights, and for railway and other engineering work; the surface will also stand much wear, and they are often employed, where their colour is not an objection, in the walls of passages and gateways subject to much traffic. Being non-porous, they are also much used for copings to walls, and in the form of paving bricks for yards and stables, and for such purposes are moulded in a great variety of forms.



Clinkers. *Clinkers* are small, hard bricks burnt at a high temperature, with a smooth, vitrified surface. For paving, the edges are generally chamfered, forming a V-shaped joint when laid; they are also employed in forming kerbs and channelling.

Fire-bricks. *Fire-bricks* offer great resistance to heat, and are used for setting stoves and boilers and in any position where such qualities are required. The Dinas fire-brick, which is extremely refractory, may be used for lining regenerative furnaces, and in other situations where exposed to intense heat.

Glazed Bricks. *Salt glazed* bricks have the surface covered with a thin transparent glaze, caused by introducing salt into the kiln during burning, the sodium combining with silica in the clay to produce the glazed surface.

Glazed or enamelled bricks have the surface covered with an opaque glaze or enamel, either white or of various colours: such bricks cannot be easily cut or rubbed and are made in a variety of forms for special positions. The glaze is produced by dipping the brick into a *slip* formed of finely-worked superior clay, with which the colouring material is incorporated, and then burning in a kiln. It is more liable to chip than salt glazing, and is more costly.

Qualities of Good Bricks. It is not possible to supply an exhaustive list of the various bricks manufactured, but after a little experience of well-known types of brick it should not be difficult to determine, in most cases, if any given class of brick is likely to be reliable. The following characteristics should be sought for in any class of bricks to be used in building.

Size. This should be uniform. If bricks vary much in size, very uneven work results. The bricks used in London average about 8·75 in. by 4·25 in. by 2·75 in. [1], but many classes of bricks are considerably larger, and some are made smaller.

Shape. The faces should be square, and the arrises fairly true and not twisted.

Absorption. This should not be excessive, and should not exceed 20 per cent. A brick should not absorb water very readily, but should give it off freely. An ordinary brick will often absorb about one-sixth of its weight of water, but a highly vitrified one not more than one-fifteenth, and some even less. Absorption may be tested by weighing a brick when thoroughly dry, completely immersing it in water till saturated, and then re-weighing it after any surface water has been drained off. The difference in the weights represents the amount of water absorbed. The tendency to absorb water readily or reluctantly may be tested by standing a brick half-immersed in water, and noting to what extent the water is absorbed by the upper half.

Uniformity in Burning. This can be observed when a brick is broken across; the colour in section will often differ from the colour of the face, but even burning should result in a uniform character and texture, and should show slight vitrification. The brick, when broken, should be free from cracks and other flaws, and from stones.

Ring. A well-burnt brick struck against another, or with a bricklayer's trowel, should give a sharp metallic ring.

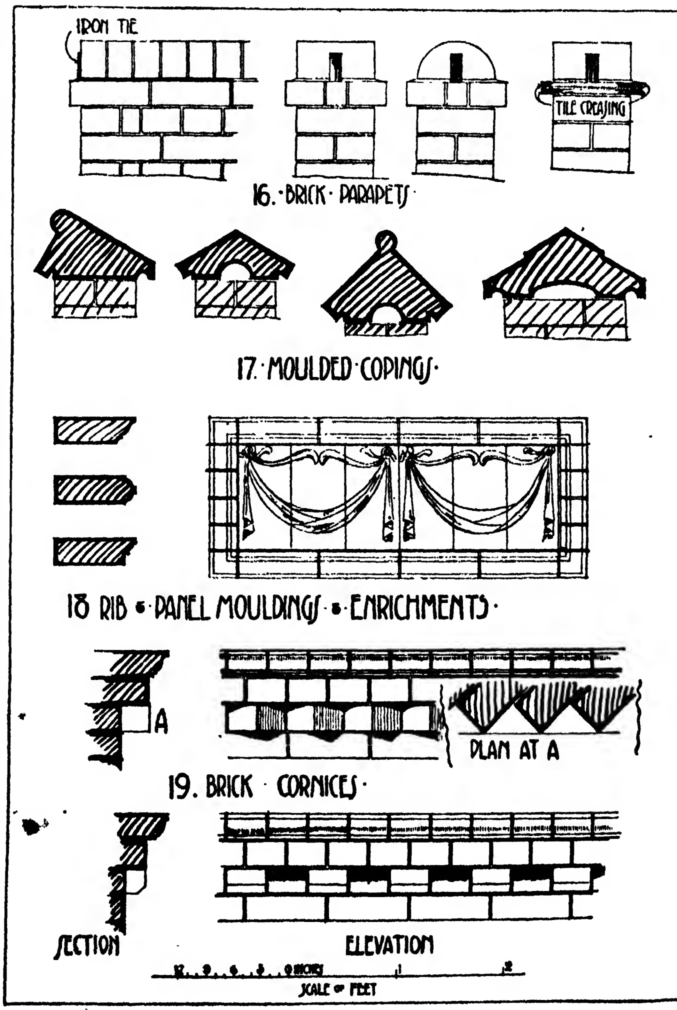
Colour. Where bricks are to be used in the face of a wall, the colour is of importance, but is entirely a matter of taste. For any work, the

colour having been selected, samples of bricks should be approved and labelled, showing the extreme limit of variation in colour or shade from the standard sample that will be accepted. It may be noted here that the general character of the colour of any piece of brickwork is materially affected by the colour of the mortar used in pointing the joints.

Judging Bricks by Appearance. The appearance of the brick will, as a rule, indicate the process by which it has been moulded. *Hand-moulded* bricks have a *frog* [1] on one side; the edges are, as a rule, not quite uniform or even, and the surfaces are somewhat rough. *Wire-cut* bricks are without frogs, and the top and bottom beds generally exhibit traces of the dragging action of the wires by which they have been cut. *Machine-moulded* bricks have sharp clean arrises, smooth surfaces, sharply-marked frog, with a trade-mark or maker's name, and sometimes a frog on both sides. Some kiln-burnt bricks are marked with dark bars, caused by the method of stacking the bricks in layers or rows at short distances apart, these bars representing the parts that have been in actual contact.

Special Bricks. Special forms of bricks are sometimes required in addition to the bricks of ordinary dimensions which have been described. It is possible to make bricks of any desired pattern and size within certain limits. Many manufacturers keep stocks of various moulds for special bricks, from which bricks can be supplied with due notice. Special shapes of bricks in frequent use are often stocked. It is also possible to have bricks specially moulded to suit any required situation, but their manufacture involves delay and some extra expense; where a large quantity of bricks of any particular form are required, it proves, however, more economical and satisfactory than cutting bricks to the required form. This is especially the case with glazed bricks. For certain work, especially that with delicate mouldings, rubbing gives much more satisfactory results than moulding. Of stock forms of bricks, the varieties that can be readily obtained, as a rule, are *splits*, bricks of ordinary length and breadth, but of less thickness. *Splayed bricks* [13] are those having a chamfer worked on one edge, made with splays of various sizes. *Bullnose* bricks [3 and 4] are those having one angle rounded or circular, on plan, the circle being usually struck with a 2¼ in. radius. Double bullnose bricks are also made, having two rounded angles. *Stops* [4, 12] for bullnoses and splays are made in various shapes when the surface is required to be brought back to a rectangular form. *Angle*, or *mitred bricks* [15] for dealing with such forms at angles, are also made, and are more satisfactory than cutting the bricks to mitre.

Moulded bricks for *plinths* [13], *strings* [14], *sills* [22], *moulded ribs* [18], *cornices* [19], *copings* [17], mouldings for *window jambs* [22], *sunk panels* [18], and similar purposes, are made in great variety. Different manufacturers make and stock different sections, and some makers include plain and enriched bricks of *voussoir* [21] shape for arches of different radii, including enriched voussoirs. All such bricks are carefully arranged to bond with ordinary brickwork, and include, as a rule, all returns, mitres, stops, etc., that are usually required.



16. BRICK PARAPETS

17. MOULDED COPINGS

18. RIB & PANEL MOULDINGS & ENRICHMENTS

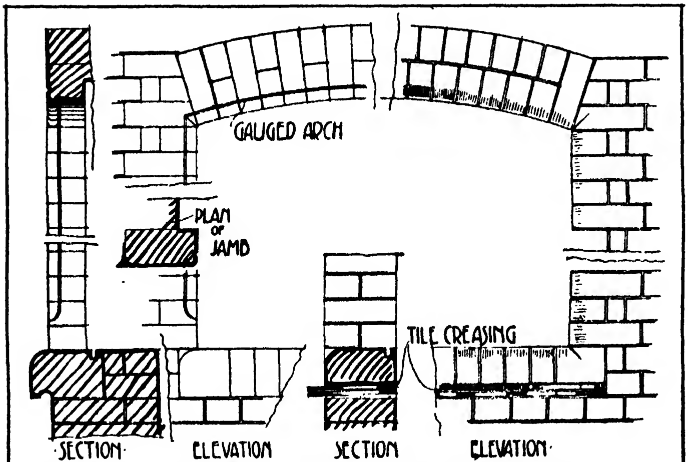
19. BRICK CORNICES

Enrichments [18] of various forms, including panels, may be moulded in brick earth and burnt, and an inexpensive form of enrichment is thus obtained, but it is inferior in effect to good carved brickwork.

Gauged Work [20 and 22] is a term applied to brickwork for which the bricks are cut or rubbed to exact sizes. When the bricks are cut the term *axed* work is used, and this treatment is employed when the bricks are of a hard texture and very fine close joints are not required. When the bricks are rubbed the work is described as *rubbed* and *gauged*. These bricks are used for the highest class of work, and are set with a very fine true putty joint, to be described later.

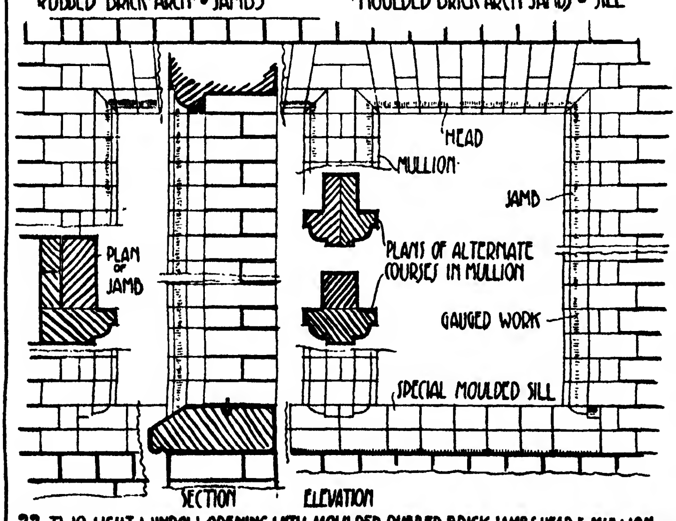
Axed Work. The tools used in axed work are the *tin saw* [24], with which, after the outline is marked, the required shape is cut in for about ¼ in.; the *bolster* [25], a short broad chisel; and a *club hammer* [26], by means of which the superfluous brick is knocked off; a *chopping block* [30], consisting of two blocks of wood secured to a base, so as to form an angle in which the brick can be placed for cutting; a bricklayer's *axe*, or *scutch* [27], consisting of a stock in which a blade about 1 in. broad and sharpened at both ends is fixed by means of a wedge.

A template of the exact size to which the brick is to be cut is prepared and placed on the external face of the brick—that is, usually, of course, the narrow, not the broader, surface of the brick—and the outline is marked on the brick and cut in with a tin saw. The position of the cuts are squared across with a *square* [35] at the ends, and the back is similarly marked and cut; the superfluous brick is then knocked off with the bolster and hammer, the brick is placed in the chopping block, and the axe or scutch used to smooth the sides, which must be carefully done, so as to ensure that they are true and do not project. The object of using the tin saw to cut in the outline is to ensure a clean, sharp arris. This class of work is chiefly used for shaping the bricks to be used in segmental and flat arches. Cutting mouldings is costly, and when required to be introduced where hard facing bricks are used, purpose or stock-moulded bricks are generally employed.



20. OPENING WITH MOULDED RUBBED BRICK ARCH & JAMBS

21. OPENING WITH BULL-NOSE MOULDED BRICK ARCH JAMBS & SILL



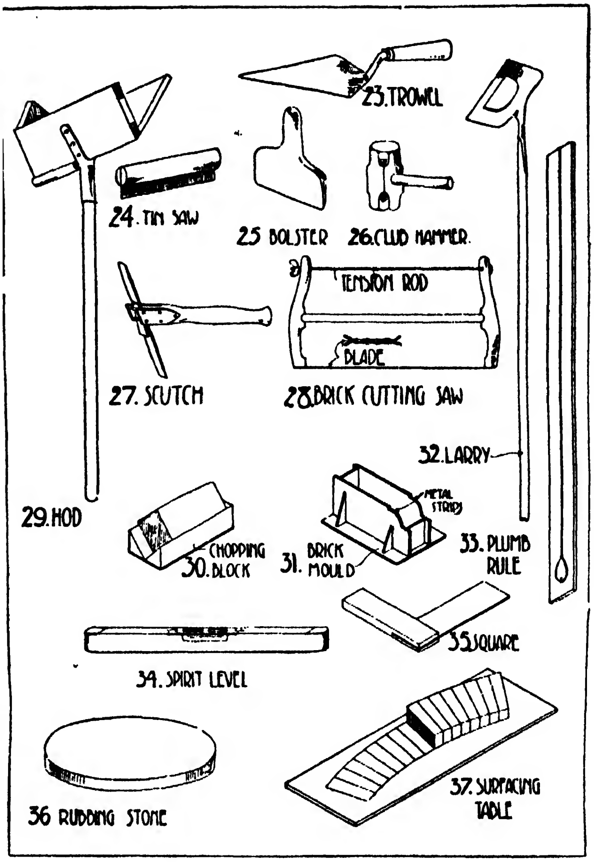
22. TWO-LIGHT WINDOW OPENING WITH MOULDED RUBBED BRICK JAMBS HEAD & MULLION

Rubbed and Gauged Work. For rubbed and gauged work the bricks employed are the rubbers already described, which are somewhat soft, and are made extra large, so that when rubbed to the required gauge and set with a fine putty joint they will bond with ordinary bricks set in mortar. Different tools are used for producing this work. The *saw* [28] consists of a frame-saw, and the blade is formed of two wires of soft steel or malleable iron twisted together and strained. This is used for cutting the bricks to the required shape. The *rubbing stone* [36] is a slab of York stone, gritty, and usually circular, and some smaller pieces of stone are required for finishing small surfaces, and flat and circular files are also employed. A *surfacing table* [37], or slab, is required, on which the worked bricks can be set up to test the accuracy of their cutting. *Moulds* [31] are also required in which the brick can be cut. These are formed of

consist of a base and of cut to the profile of the re- brick, but a little full. They fened with brackets, and the surfaces covered with strips of so that they are protected from ge when the saw-blade works r them.

This class of work is used for plain walling, which is the simplest work, and for straight mouldings; also for circular work, either plain or moulded, and for what is known as *circle on circle* work, in which a double curvature occurs.

In working a brick for plain work a beginning is made with one broad surface. This is rubbed on the rubbing stone with a sweeping motion till perfectly true; next one edge is similarly worked, so that it is perfectly true, and is tested with a square to ensure that it is at right angles to the face first finished. It is then placed in a mould of the size required to give it the necessary thickness, tightly wedged, and the upper part is removed with a saw; and by the use of similar moulds the width and length may also be reduced to exact dimensions, and the sawn surfaces are afterwards rubbed or finished with a hand-stone or file. For moulded work, or for circular work, the wood moulds are prepared of the necessary form, and the process is similar though not quite so simple.



Rough Cutting. We have now considered the manufacture of various forms of brick, most of which the bricklayer is able to lay just as they are delivered on the scaffold, and we have also described the careful preparation of bricks for special situations by different processes, which are all covered by the general term *fair-cutting*. Such bricks are not prepared on the scaffold by the bricklayer, but in a shed, and are sent to the scaffold ready for fixing.

For many situations, however, some cutting on the scaffold is necessary, and this is generally termed *rough cutting*. It includes the rough shaping of bricks by the bricklayer's trowel to suit special positions, the cutting off of angles of brickwork with a hammer and chisel before plastering, and the cutting of perforations and chases, and generally such work as does not involve forming a carefully finished face to the cut surface.

Uniting Brick to Brick. All walls or other structures built up of a number of blocks of materials of moderate size compared to the total mass, require that some means be taken to secure the combination of the component parts into a solid structure. In very favourable circumstances, where the individual blocks are comparatively large and finely wrought, friction by itself may suffice, as in some of the old Greek buildings. But, even when such materials were used, ties of bronze were largely utilised for uniting adjacent blocks and courses. Such work involves much labour in preparing the stones with true beds and joints, and in fitting in the ties.

Where the blocks are comparatively small, such a system is not practicable, and the usual practice has been, and still is, to fit them together with the help of some material that will bind them together. There is this further advantage in the use of such material, that it is not necessary to prepare the beds and joints with the same scrupulous care as when they are to come into actual contact, when perfectly true beds are required to secure an even bearing. The materials in general use for this purpose are all of them applied in a soft condition, and allow for slight irregularities in the adjacent surfaces, and the extent to which such irregularities exist will determine the thickness of the material used in the joint. For example, when bricks are used as delivered on a building, if they are placed one upon the other it will be noted that any two surfaces, as a rule, are not in contact all over, and in practice it is usual to form a bed or joint of about ¼ in. thick. If, for any reason, a very fine joint be required, the bricks have to be prepared by rubbing the adjacent surfaces till they are quite true. Much the same is true of stone walling. If small stones be used with rough

surfaces, thick joints are necessary, and if a fine joint be required, the surfaces must be carefully prepared.

Mortar for Brickwork. The material used for forming these joints between the hard blocks of material is usually described as *mortar* or *putty*. Bitumen has been employed in countries where it is found, but is not a cementing material in ordinary use. Mortar varies considerably in its nature and properties, according to the ingredients of which it is composed. The word usually implies a material composed of a fine *aggregate* [see page 880], such as sand, and of some form of lime as a *matrix* [see page 880]. *Cement mortar*, often referred to briefly as *cement*, consists of a similar aggregate mixed with Portland cement, or some other cement. It is a material similar to concrete, but requires a very much finer aggregate.

Mortar Aggregate. The aggregate for mortar is usually *sand*, which may be pit sand or river sand, and is required to be clean, sharp, free from all animal and vegetable impurities, and from loam or salt. If necessary, it must be washed, as described for use in CONCRETE [page 881]. If the sand be mixed with gravel or stones, it may be screened. This is done by erecting near the heap an oblong frame of wood, filled in with a series of stout wires running vertically. For ordinary mortar, these are usually ⅛ in. diameter, with three wires and three spaces to 1 in.; stronger horizontal wires occur at short intervals. The frame is fixed in an inclined position; the material to be screened is taken from the heap in a shovel and thrown against the face of the screen; the finer particles, forming sand, pass between the wires and fall behind the screen; the larger particles and stones run down the face of the screen, and are reserved for concrete.

Various substitutes may be employed if sand cannot be obtained, or may be used as a portion of the aggregate, provided the particles are sharp, clean, and durable. The most usual substitutes are crushed sandstone, crushed pottery, or crushed brick, but the bricks for such purposes must be thoroughly burnt, hard, and vitrified, and, if old bricks are used, should be cleansed of any old plaster adhering to them. Fine ashes often make a very satisfactory mortar, but give it a dark colour.

Qualities in Mortar Aggregates. Whatever the aggregate employed, it must be clean; particularly it must be free from salt, which would cause dampness and efflorescence in the mortar, and from loam or clay, which would prevent the matrix adhering to the particles. The presence of loam may be detected by rubbing a small quantity in the fingers when it is damp. If loam be present, the clay will be rubbed off, and remain as a slightly sticky yellowish substance on the fingers. The only means of getting rid of such matter is by washing as already described.

The sharpness, which is also essential, may be detected by employing a magnifying glass, when the grains should appear irregular and angular, not rounded and smooth. Sharp sand, if rubbed between the fingers close to the ear, w ked off; sharp grating sound.

Quality of Lime for Mortar. blocks matrix selected depends largely upon th rm an pose for which the mortar is required, and for strength expected in the walling. A pure c [27], lime should never be used in making mor bout except for temporary work, where no streng is is required; such lime can set only by the absorption of carbonic acid from the air, which never reaches the inner portions of a bed of mortar, and in consequence this never sets. A feebly hydraulic lime, such as the greystone lime burnt in the neighbourhood of Halling, Dorking, or Merstham, may be used for ordinary building work in which no great strength is required to be developed, but is not suitable for footings in damp situations. Blue lias lime, which possesses considerably higher hydraulicity, is used for building of a good class, and may be utilised even for foundations in damp situations. The most eminently hydraulic are Aberthaw and Halkin Mountain lime, but where an eminently hydraulic material, or one possessing great strength is required, Portland cement is usually specified. Other cements, such as Roman, are confined, as a rule, to rendering or covering walls externally.

Composition of Mortar. The sand in mortar is employed partly for reasons of economy; it also serves to lengthen the time within which setting takes place, and renders the material easier to use; but it diminishes the strength of the resulting mortar, and the proportion in which it is employed is, therefore, regulated by these considerations. The proportions of aggregate and matrix usually employed are the following:

1 part of feebly hydraulic lime, 2–3 parts aggregate; 1 part eminently hydraulic lime, 3–4 parts aggregate; 1 part Portland cement, 2–3 parts aggregate.

Portland cement is usually mixed with a comparatively small proportion of aggregate. Its strength is greatly reduced if a large proportion of aggregate be employed, and as cement is, as a rule, employed mainly where considerable strength is essential, it is important that it should not be seriously impaired.

Experiments by Grant showed the results given in the following table:

1 part	P.C.	+1	part	sand	= 75	per cent.	of neat	Portland cement.
1	,,	+2	,,	,,	= 50	,,	,,	,,
1	,,	+3	,,	,,	= 33	,,	,,	,,
1	,,	+4	,,	,,	= 25	,,	,,	,,
1	,,	+5	,,	,,	= 17	,,	,,	,,

They also demonstrated that it takes a much longer time for the cement mortar to attain its ultimate strength when a large proportion of aggregate is employed.

The methods of slaking limes and cements for using in mortar have already been described, and the nature of the setting, but the method of mixing may be briefly referred to.

The Mixing of Mortar. Much will depend on the amount of mortar required daily. If this be small the mixing will be done by hand,

...rge works a mortar mill is often used. ...se of a mortar which sets slowly there ...eat harm in mixing up more mortar than ... used in a single day; but in the case of ...s made with eminently hydraulic limes ... cements this must on no account be p...wed. Where a quick-setting cement is ...ixed with a small amount of sand, it must be ...ade fresh and used up before setting begins. ...n any case, mortar cement that has once set should not be allowed to be "knocked up again"—that is, mixed with a further supply of water till it is soft and then employed as mortar. This is a practice that is often indulged in and even supported, but should not be allowed, for such mortar or cement may reset, but it will never attain the strength that freshly-made mortar would do.

Working up by Hand. In working up by hand it is usual, if the lime be in lump, to measure out the amount of sand and lime required, to form a roughly circular ring of the sand, or other aggregate, to place the lime within it, to sprinkle it with water, and to leave it till slaking has taken place. When this is complete more water is added, the sand from the ring is gradually worked into the centre with a spade or shovel, and incorporated with the lime by means of a *larry* [32], which resembles a large hoe with a long handle, and with a hole formed in the blade. With the larry the mortar is worked over till all the sand is incorporated and thoroughly mixed. Mortar so made is often kept for a day or two before use to ensure that the lime is thoroughly slaked, but this method only applies, as a rule, to pure and feebly hydraulic limes; the more eminently hydraulic limes and cements are usually ground.

Transporting Mortar. With ground limes and cements the proper proportions of aggregate and matrix are usually mixed dry, the necessary water added, and the whole intimately mixed, and conveyed as soon as possible to the scaffold for the bricklayers' use. This may be done in *hods* [29], which are made of such a size that they can also be used for carrying bricks, and are filled and carried by labourers to the point of use and tipped out on to *mortar boards*, boards about 30 in. square, from which the bricklayer picks the material up with his trowel [23], in building the wall on which he is working. In larger works it may be put into barrows or baskets or pails, and hoisted to the scaffold; in such cases the mortar is usually mixed as close as possible to the bottom of the hoist.

The Mortar Mill. Where a large and regular supply of mortar is required, a mortar mill is best employed; but this requires an engine or motor to drive it in most cases, though smaller mills worked by hand or by a horse have been used.

The mill used for mixing mortar consists of a circular iron pan from five to ten feet in diameter which revolves round a central pillar by means of machinery under two heavy rollers weighing together from one to three tons, and iron plates are used to direct the mortar, during mixing, under the rollers. Lime in lumps must be previously slaked. The ingredients are fed into the pan in their correct proportions, including a proper quantity of water, and are intimately mixed by the rollers. Where the aggregate requires to be crushed before use—as, for example, in the case of old brick, stone, pottery, etc.—the crushing should be performed by the rollers before the other ingredients are added.

Setting Gauged Work. Where rubbed and gauged work is employed it is not usual or possible to set it in ordinary mortar, which would be too coarse for the fine joints that are required in this class of work, but it is customary to set all such work that is accurately finished before setting in pure lime putty. This is slaked and run into a bin, and kept moist till required for use, and is then worked up into a consistency resembling cream; the brick to be set has the surface dipped into the putty, and is then placed into position, and gently driven against the next brick. When this brick is set the putty should fill the joint and stand slightly in front of the general face like a small bead, which is afterwards cleaned off, and there should be no gaps, or cavities apparent on the face of the thin mortar-bed, which is usually not more than $\frac{1}{16}$ in. in thickness.

The joint being so fine, the use of lime without sand is permissible; but with thicker joints it would be undesirable, apart from the question of cost. Lime tends to contract somewhat during the process of setting, and it is partly on this ground that it is usual and desirable to add a fairly large proportion of sand or other incompressible aggregate in making lime mortar. Were this not done, in a lofty wall the loss of thickness in a great number of mortar joints would be very marked, and even with the usual proportion of sand there is a quite appreciable reduction in the height of brickwork laid in lime mortar during the process of setting.

Setting Gauged Work for Carving. A bed of lime putty never attains great hardness or strength, and is not suitable for use where the surface of the brick has afterwards to be cut away, as it must be when brickwork has to be carved. For such work it is usual to employ a mixture of white lead and shellac in forming the joints, and this, when set, allows the work to be treated by the carver as though it were a solid mass. Such carving should not be very deeply cut in—certainly not to such an extent as to penetrate the full depth of a brick below the original face, and where carving exceeding about 3 in. in projection is required it is desirable to construct the gauged work exclusively of headers.

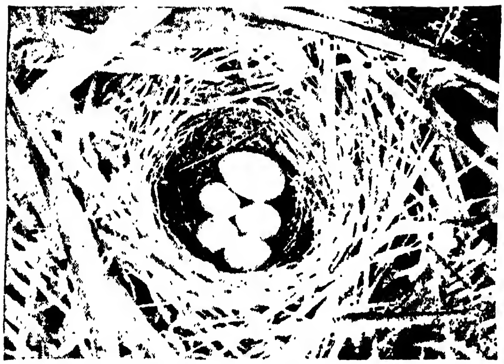
It is not necessary to use this material in cases where the work is entirely finished before fixing, as is usually done with all moulded work round openings, and in the case of all plain walling or corbelling executed in gauged work and not intended for carving.

R. ELSEY SMITH

THE SNUG LITTLE HOMES OF BRITISH BI

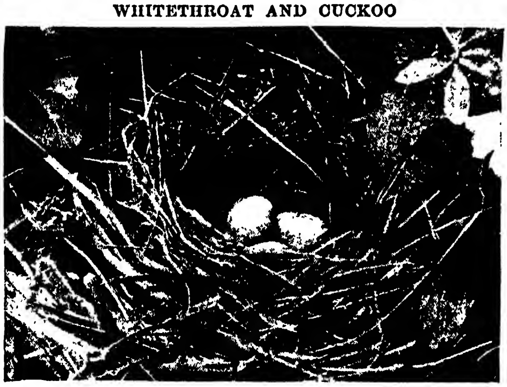
CHIFFCHAFF

PARTRIDGE



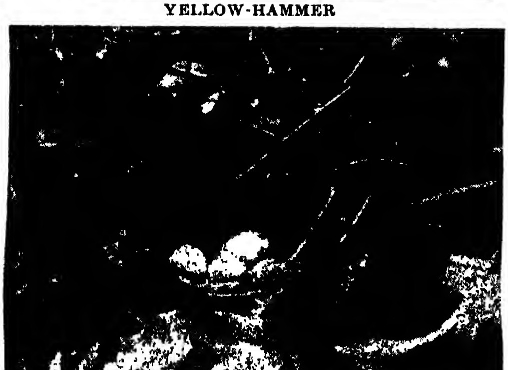
WHITETHROAT AND CUCKOO

HEDGE-SPARROW



YELLOW-HAMMER

SONG-THRUSH



LINNET

BLACKBIRD

Meanings and Colours of Plumage and Eggs. Birds as Lovers. Architecture of Nests. Varied Materials. The Cuckoo.

COURTSHIPS AND NESTS OF BIRDS

Protection against Cold. It is important that the body of an aquatic bird should be protected against chilling, which is all the more necessary because the temperature of the blood is higher than in any other animals. This is effected in two ways. There is a good deal of fat below the skin, which plays the same part as the blubber of seals and whales. And, besides this, there is an oil gland under the skin on the upper side of the tail. By means of the beak the oil is applied to the plumage, which, therefore, never really gets wet. It may also be added that the large amount of air entangled in the feathers prevents the escape of heat from the body, and this applies to birds in general, not merely to aquatic ones.

Protective Colouration. The colours of birds can be referred to the same classes as those of mammals already described.

Protective colouration is exemplified by many eggs which are exposed to view, by most young birds which run from the egg, and by a large number of adult birds of both sexes. The last is more particularly true concerning female birds, which are very often inconspicuous or even dowdy in appearance, their preservation being more important for the species than that of the more volatile males, which do not as a rule play so important a part in the rearing of the young.

Aggressive Colouration. Aggressive colouration is seen in some of the birds of prey, which harmonise in appearance with their surroundings, and are therefore not so likely to be perceived by their intended victims. This, however, is not so important as in mammals, for such forms mostly rely upon sudden and rapid flight for securing their meals. Beautiful courtship colours are often to be noticed, generally in the male. Warning colouration, advertising powers of defence, is exemplified by some of the noisy and quarrelsome friar-birds of the East Indies, and these serve as models to certain inoffensive orioles, which unconsciously mimic them, and thereby are able to exist in comparative peace and quietness. Black and white recognition markings, as in the case of antelopes, are to be found in many of the plovers, and probably enable members of the same species to know one another at first sight. The jewel-like tints of humming-birds perhaps have this significance.

Courtship of Birds. It is only natural that the tender passion, which quickens the sluggish pulses even of cold-blooded amphibians and fishes, should stir to its profoundest depths the restless bird-nature. The coy female is courted by devices of the most varied nature. It may be that the male is aided by colours of the most resplendent kind, of which extreme cases are afforded by the bravery of the cock-pheasant and the wonderful tail-feathers of the peacock. Even the familiar inhabitants of the farmyard illustrate the same phenomenon, as may be seen in the turkey. Sometimes there is no great difference in the external appearance of the sexes, as in swans.

Dance and Song. There are a number of birds the brightly coloured or otherwise decorated males among whom execute strange love antics and amatory dances, not without their effect on the opposite sex. In many forms comparatively dull plumage is fully compensated for by the possession of powers of song, and such love-ditties constitute for us one of the subtlest charms of returning spring. As among many mammals, the males are particularly combative during the spring, especially in species which are of polygamous habit. A good example is found in a bird of the plover kind, the ruff (*Machetes pugnax*), in which the cock-bird grows a beautiful feather frill round his neck at the pairing time.

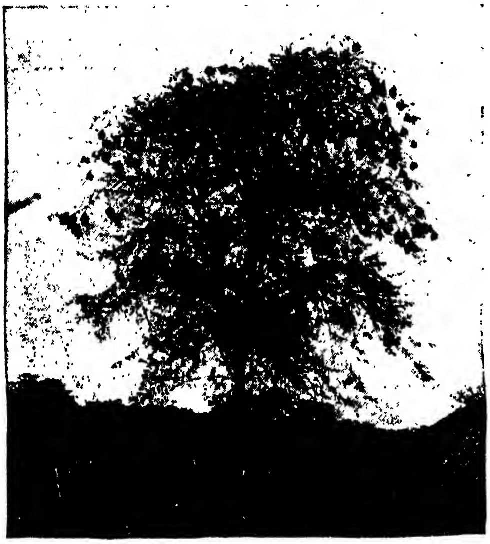
A Female Wooer. It sometimes happens that the rules of courtship are reversed, the hen, in this case the more brilliantly coloured, playing the active part, and paying her suit to the retiring male. A kind of plover, the dotterel (*Eudromias morinellus*), illustrates this highly indecorous—or, shall we say, "advanced"?—procedure.

Nesting Habits of Birds. The mound-builders and their allies (*Megapodes*), native to the hotter parts of Australia and the islands to the north of that continent, resemble reptiles in the fact that they do not incubate or sit upon their eggs and hatch them out by the heat of their bodies. Some of them simply deposit the eggs in hot sand, while others, such as the brush-"turkey" (*Talegallus*), deposit them in a huge mound of dead leaves and other vegetable matter, the decay of which generates a sufficient amout of heat for the purpose. The young, when hatched out, are in a very advanced state, and quite capable of looking after themselves, as is necessary, considering that the parents do not trouble their heads about them. The forms in question appear to be the least highly organised members of the group of game-birds.

Care of Eggs and Young. All other birds incubate their eggs, and take more or less care of their young. Even the much-maligned African ostrich takes some pains in this direction. A number of females scrape out a hole in the sand, and the necessary heat is supplied by the sun during the day, and the cock-bird at night.

It may be remarked in general that eggs which are simply laid on the ground, or in a more or

less careless nest in this position, are protectively coloured, and often very difficult to detect on that account. The young run from the egg, and are also protectively coloured. In cases where the nests are cunningly hidden, or situated in inaccessible places, the young are helpless



NESTS OF WEAVER-BIRDS IN UGANDA

nestlings. Here, too, as a rule, but not always, exposed eggs are protectively coloured, while those comparatively hidden from sight are generally white or pale in hue.

The Protective Colour of Eggs. The colours of eggs, however, still require a great deal of investigation; and if many amateurs who at present are merely egg-collectors would seriously turn their attention to the relations of colour to surroundings, their labours would in all probability be amply rewarded. Some of our natural history societies are doing good work in explaining the meaning of structure, form, and colour with reference to habit in various animal groups, and if all would combine to this end much might be accomplished. Simple naming and collecting are waste of time, except as a preliminary to serious research of the kind indicated, or with reference to distribution and general questions of this nature. The student will find our natural history museums, now established in most towns, of the greatest value and assistance in his researches.

Some of the plovers simply lay their eggs among shingle or in stony places, and these are so like mottled stones as to deceive all but very experienced observers. The chicks have an interesting habit of squatting when alarmed, when they become quite as inconspicuous as the eggs. All those who take a special interest in the nesting habits of birds, and have the opportunity, should carefully examine the splendid collection of eggs and nests in natural surroundings contained in the Natural History Museum at South Kensington, an institution which in this and many other directions illustrates the romance of science in an unusually striking manner. The common sandpiper (*Totanus hypoleucus*) constructs a careless nest, containing four protectively coloured eggs, in the neighbourhood of gravelly streams. The black-headed gull constructs a rough nest with three eggs.

Materials and Positions of Nests. The yellow-hammer constructs a hair-lined nest on or near the ground, while that of the blackbird is lined with grass, and usually to be found in hedges a few feet above the ground. The hedge-sparrow lays her clutch of bluish eggs in a cup-shaped mossy nest, lined with hair and down, and placed in the recesses of a hedge.

The nest of the greenfinch, constructed of twigs and wool, and lined with hair, is to be found in high hedges. That of the garden-warbler is to be seen among bushes in gardens, and is constructed of grass, lined with finer materials of a similar kind. In small trees and bushes, near open spaces, may be discovered the nests of linnet and lesser redpoll. The former is made of twigs and moss, lined with wool, hair, or feathers, and the latter of twigs and grass, lined with down.

The beautiful, hair-lined, mossy nest of the sedge-warbler (*Acrocephalus phragmites*) is lined with hair, and either actually suspended among sedges or built in bushes adjoining the water. Another type is presented by the nest of the song-thrush, generally placed in hedges, and lined with mud. The plaster lining is made smooth by the bird turning round and round in the nest, using her breast as a trowel.

Well-built Nests. A distinct architectural advance is seen in the tree-nest of the chaffinch, exquisitely made of moss, lichen, and

THE KINGFISHER'S NEST IN A RIVER BANK—SHOWN IN SECTION

fibre, lined with hair and down. In this, and many other elaborately woven homes, the sticky saliva is used as a cement. From such a case we may pass to such a beautiful domed nest as that of the long-tailed tit (*Acredula caudata*), where a roof is added to the cup-shaped base.

NESTS IN HEDGEROW, MOOR, AND STREAM

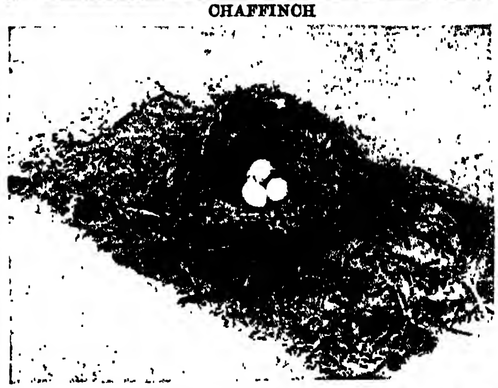
WHINCHAT

BULLFINCH

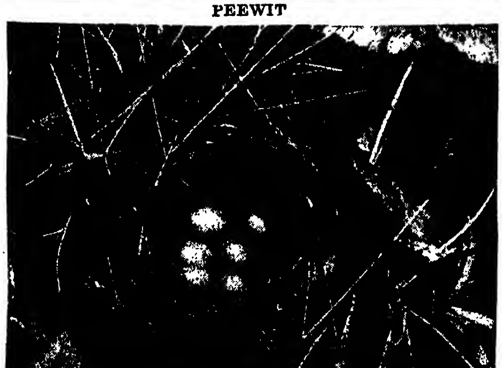
GREENFINCH

CHAFFINCH

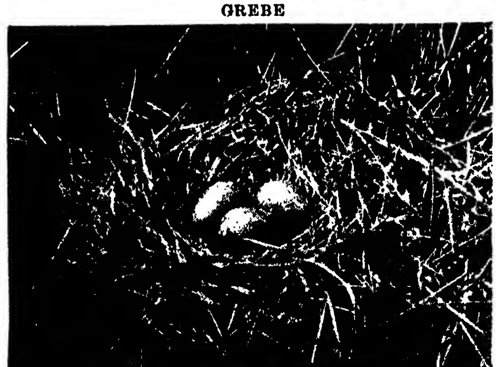
PEEWIT



GREBE



SEDGE-WARBLER



BLACK-HEADED GULL

Some of our birds of prey build stick-nests with a softer lining, and a careless structure of similar kind is constructed by the wood-pigeon, the white eggs of which may be clearly seen from below through the interstices. The black, ragged nests of the social rook are of similar material, more closely compacted together. Similar, too, is the nest of the magpie, commonly to be found in thorn-bushes, for greater security.

Communal Homesteads. The picucules, or tree-creepers, of South America build nests of the most varied kind, among which are those of the oven-bird (*Furnarius*). These are of clay mixed with fibre, and a sort of ante-chamber leads to an inner compartment, where the eggs are laid upon a layer of grass. Much more remarkable than these, and probably the most extraordinary outcome of bird architecture, are the communal grass nests of the sociable grosbeak (*Philhœterus socius*) of Africa, in which from one to three hundred pairs combine to produce a compound structure, built round the trunk of a tree, and covered with a common roof, so as to suggest a gigantic mushroom in appearance.

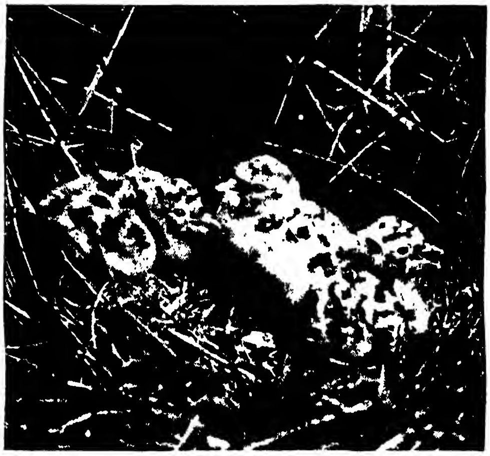
Edible Birds'-Nests. The clay nests exemplified by the oven-birds suggest those of similar material constructed under the eaves of barns and the gables of houses by the house-martin, and shaped like half a saucer. The clay pellets are cemented together by saliva. Similar in shape are the edible birds'-nests of the East, but these are entirely made of hardened saliva. They are constructed by swifts, and are highly valued by the Chinese as an article of diet. The Indian tailor-bird actually sews leaves

A WOODPECKER'S EGGS IN A TREE-TRUNK

together into a funnel-shaped nest, and the fan-tailed warbler stitches grass-stems together above its globular nest. It is even said to make a knot in the end of the thread.

Some birds prefer to lay their eggs in places far removed from sight. The sand-martin, for instance, digs out a tunnel in a sandbank, and brings up its young at the end of this, upon a bed of down. Somewhat the same is true of the kingfisher, but here the bed is made up of disgorged fish-bones.

Homes Dug Out of Trees. Woodpeckers excavate a cavity in the trunk of a tree, and lay their eggs at the bottom of this, while the nut-hatch uses a ready-made hollow for the purpose, and contracts the opening with



NESTLING BLACK-HEADED GULLS, SHOWING THEIR PROTECTIVE MARKINGS

mud, leaving only just enough space to serve as a door. One of the most extraordinary instances of nesting in a hollow tree is afforded by some of the hornbills of Africa and Asia. Here the hen-bird is actually built in with clay, probably by her mate, who at any rate feeds her with the greatest devotion during the enforced seclusion.

Feathered Foundlings. We have, lastly, the curious habit of brood-parasitism, exhibited by the cow-birds of South America and our native cuckoo, which deposit their eggs in the nests of other birds. These eggs are apparently, at least in the cuckoo, not laid in this situation, but carried there in the beak of the hen-bird. The hedge-sparrow and several other of our native perchers are victimised in this way. An illustration on page 2462 shows a cuckoo's egg in the nest of the white-throat. The young cuckoo develops more quickly than its unfortunate foster brothers and sisters, whom it ousts from their legitimate home, pushing them over the edge of the nest to perish. In this inhuman proceeding it is aided by a hollow between the shoulders, which later on disappears. The misguided foster-parents tend the unnatural guest with the greatest assiduity, and have hard work to satisfy its inordinate appetite. The intelligence of birds obviously has strict limitations.

The eggs of the cuckoo undoubtedly vary a good deal in appearance, and it has been asserted that they commonly resemble those of the particular species selected as a victim. This is, however, extremely doubtful.

J. R. AINSWORTH-DAVIS

Electric Lamps in the Making. The Filament. Obtaining the Vacuum. Lighting Efficiency. The Tungsten, Tantalum, Mercury Vapour, and Other Lights.

GLOW LAMPS

THE story of the development of the electric incandescent lamp is one of the romances of electrical engineering. For many years it was known that platinum wire could be heated to incandescence by an electric current, but every attempt to utilise it in a lamp failed. By the year 1878 the need for a domestic lamp was urgent, and many experimentalists were trying to find a suitable material for the lamp filament. It was generally felt that carbon was the most promising substance, but the difficulties in the way of using it seemed insuperable. At length, late in 1878, or early in 1879, Swan in England and Edison in America solved the problem independently at practically the same time. Swan made a very thin carbon filament by carbonising some cotton thread which had been previously parchmentised. Edison carbonised very thin strips of Japanese bamboo fibre. Both inventors then secured their filaments to platinum leading-in wires, and placed them in glass bulbs, which were sealed up after all the air had been carefully exhausted. The success of the new lamp was complete, and for twenty years improvements in detail only were made.

The Coming of the Metal Lamp. During these years great progress had been made in the business of public electricity supply. The convenience of domestic electric lighting was generally acknowledged. The principal objection was its cost. And then attention was turned to the metal filament, of which platinum was the prototype.

The cause of the failure of platinum was seen to be its comparatively low melting-point, and experiments were made with the more infusible metals which were not available at the date of the earlier experiments. The partial success with osmium, the better results obtained with tantalum, and finally the tungsten lamp form a record of triumph over difficulties that it would be hard to beat in the annals of industrial progress.

The Carbon Filament Lamp. Carbon filaments possess many of the requirements essential to successful electric glow lamps. These may be said to be: high fusing-point; high electrical resistance; easy manipulation, so that the filaments can be made into fine threads of uniform quality and size; good efficiency, enabling a given amount of light to be obtained for a reasonable amount of electrical energy; and great durability, so that the lamp may have a long life without serious deterioration of candle power. Although in some directions they have recently been superseded by metal lamps, carbon filaments are still made and used in vast quantities.

How Filament is Made. Following on the early work of Edison and Swan, many efforts were made to obtain more uniform filaments. For some years manufacturing practice has been crystallised into the following process:

Best bleached cotton-wool is dissolved in a warm solution of zinc chloride in water. The mass which results has the appearance of thick treacle, and must be freed from air-bubbles and uncombined water by being placed in vacuum. It is then squirted under pressure through a glass nozzle, and passes into a mixture of methylated alcohol and hydrochloric acid. The acid removes all the water from the jelly-like thread, from which all trace of organic origin has thus been removed. This thread contains the carbon which is going to form the incandescent filament, but it is at present in a state where the carbon is combined chemically with hydrogen and oxygen, and intimately mixed physically with zinc chloride. After three or four days it, is taken out of the liquid and carefully washed with water, and wound on a cylinder to dry.

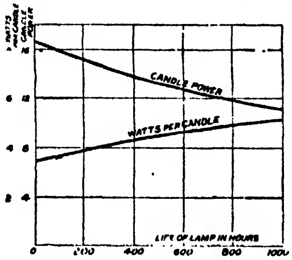
The next process is to wind this flexible thread upon blocks, to give to the loops the shape they will afterwards have in the lamp. The blocks are then packed tightly in boxes with charcoal dust, and the boxes containing them are subjected to a gradual and prolonged heating up to 2000° C. During the heating the cellulose is transformed into a shiny and extremely flexible black filament, which is very hard.

Flashing the Filament. After being gauged and cut, the filaments are cemented to platinum leading-in wires. This is usually done by electrically heating the joint in benzene, or a similar hydrocarbon, with the result that a deposit of carbon takes place at the point of contact of carbon and platinum.

In order to make a final adjustment of the resistance of the filament, and also to thicken up any defective places, it is *flashed*—that is, heated to bright incandescence in a jar containing coal-gas, or sometimes benzene vapour. The gas is decomposed in the presence of the glowing filament, and a layer of solid carbon is deposited which is thickest at the places where the filament is hottest—that is, at the thin spots. In this way a uniform sectional area and resistance is secured.

Completing the Lamp. The mounted filament is sealed into a glass bulb, and placed in communication with an air-pump. Usually about 99 per cent. of the air is taken out by a mechanical air-pump. The remainder is extracted by means of a Sprengel pump, in which mercury is kept circulating in fine glass tubes over a barometric vacuum. When the process is nearly

complete it is necessary to warm the bulb, and at the same time to overrun the filament momentarily in order to expel the last traces of hydrocarbon vapour. The last traces of oxygen are now often removed by introducing a small quantity of phosphorus. This combines chemically with the oxygen, and at the same time forms a white smoke, which helps to sweep out any other gas from the bulb.

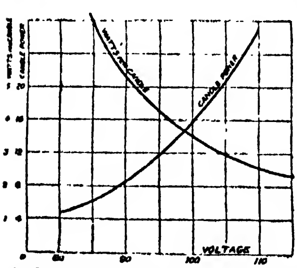


202. AGEING OF LAMPS

As soon as the vacuum is complete the bulb is sealed up, and after capping and marking is ready for use.

Voltage, Candle Power, and Efficiency. Owing to the shape of a glow-lamp filament, the candle power emitted at different angles varies within wide limits.

Thus **204** shows the candle power of a lamp measured at different angles on a horizontal plane with both a clear and a frosted bulb. Lamp manufacturers use as a standard the mean horizontal candle power taken as a mean of several readings at different angles or one reading taken at a mean angle. This is sufficient for most commercial purposes, as it forms a basis of comparison for different lamps. A more accurate comparison is to take readings at different angles in all directions, and so get the mean spherical candle power. For street-lighting work, it is very usual to speak of the mean hemispherical candle power, meaning the mean of all the light below the horizontal plane of the lamp.



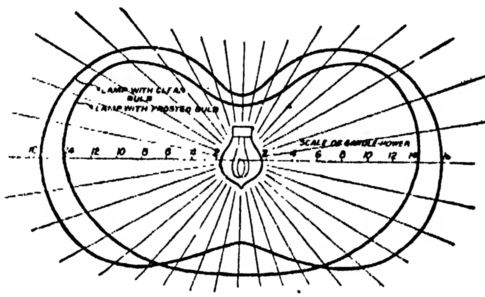
203. EFFICIENCY AT VARIOUS VOLTAGES

The efficiency of a lamp is the ratio of the total watts taken by the lamp to the candle power (in commerce, the mean horizontal candle power). This varies with the voltage. For instance, if a 16 candle-power carbon lamp consumes 3·5 watts per candle at 100 volts, careful tests made with other voltages would give the approximate results below [203]:

Voltage at terminals of lamp.	Candle Power.	Watts taken for each candle-power.
80	4·6	—
85	6·3	7·0
90	8·5	5·3
95	11·9	4·24
100	16·0	3·5
105	20·7	2·9
110	27·2	2·5

Expressed mathematically, this means that the candle power varies as the sixth power of the voltage. The prospects of high efficiency which the use of overrun lamps seems to promise is, however, neutralised by the deteriorating effect upon the useful life of the lamp, which results from over-running. All carbon lamps deteriorate with use, and this deterioration is the more rapid the higher the temperature at which they are used.

The Life of an Electric Lamp. The *life*, or the time during which an electric lamp will burn before breaking, when used at normal voltage, may be anything from 1000 to 2000 hours. During this time, however, the lamp is slowly losing its power and efficiency, and it may be advisable to discard it long before it would finally break. The deterioration appears to be due mainly to two causes: (1) a decrease in the conducting quality of the carbon, so that its resistance goes up and its surface becomes less powerful in emitting light; and (2) the few



204. THE DISTRIBUTION OF LIGHT FROM AN INCANDESCENT LAMP

millions of molecules of gas still left in the bulb after the exhaustion process, in their violent to-and-fro movements, impinge upon the white-hot carbon, convey particles of it away, and deposit them on the surface of the bulb. The decrease in power and efficiency is shown in the following table, from which curves in **202** are plotted. The figures are compiled from experiments carried out on forty-eight 200-volt lamps of various manufactures:

Time of burning in hours.	Candle-power at end of time.	Watts per c.p. at end of run.
100	15·9	3·81
200	15·0	3·98
300	14·3	4·13
400	13·7	4·29
500	13·1	4·45
600	12·6	4·60
700	12·2	4·72
800	11·8	4·88
900	11·5	5·00
1000	11·3	5·08

The British Engineering Standards Committee base their systems of rating carbon lamps on this effect. They insist that from every batch of lamps samples shall be taken which shall afterwards be photometred at an angle of 45°. The lamps are then to be run on a constant voltage circuit, and periodically photometred. The useful life of the lamps is assumed to be the time during which, if run at constant voltage, the candle power does not fall more than 20 per cent. below the starting candle power. Limiting

starting efficiencies for lamps tested under these conditions are given. From the above considerations it will be seen that an increase of voltage over the normal value has serious effects upon the useful life of the lamp. This is the case, as the following table shows.

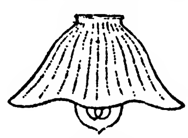
Percentage of Normal Voltage.	Percentage of Normal Life.
100	100
101	88
102	68
103	56
104	45

Before the introduction of metal lamps efforts were made with some measure of success to reduce the blackening effect of high efficiency by using specially large bulbs.

If, as shown above, the efficiency of a lamp falls with use, there must come a point when the increased cost of the current required for a given candle power exceeds the saving which could be made by using a new lamp. This point, termed the *smashing point*, depends upon the inefficiency of the lamp, the cost of a new lamp, and the cost of current; but with electric energy at less than 4d. per B.O.T. unit it comes much sooner than many people think.

Special Carbon Lamps. Many efforts have been made to improve, from an electrical point of view, the carbon filament. One of the most successful had been to submit it to the intense heat of the electric furnace. This operation, twice repeated, removes the ash residue and hydrocarbon, and produces a much more refractory filament which is able to withstand higher temperatures than the ordinary filament. This intense heating is also stated to cause the resistance of the filament to increase as the temperature rises, instead of to fall as in the ordinary lamp. A 16 candle-power, 100-volt lamp of this type has a consumption of only 2·8 watts per candle power, and an average useful life of about 1500 hours. Under the name of "Gem" lamps they are largely used in America, and to a small extent in this country.

205. SHADE FOR DISTRIBUTING LIGHT



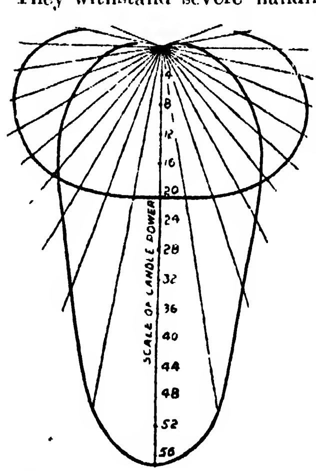
206. SHADE FOR CONCENTRATING LIGHT

The Metal Lamp. Modern metal lamps are made of either tantalum or tungsten. Both are rare metals, difficult to obtain in the metallic state, and when obtained are very difficult to work. The Tantalum lamp is very largely the work of Dr. Werner von Bolton, of Messrs. Siemens & Halske, who has devoted years to perfecting it.

The tantalum is made by a process which may be briefly described as reducing in vacuo potassio-tantalo-fluoride. The metal is obtained in the form of a black powder, which, after being fused electrically, is drawn into very fine wire. Owing to the fusing-point of tantalum being lower than that of tungsten, it cannot be run at such a high efficiency, and usual figures for the consumption are 1·8 to 2·0 watts per British candle power for lamps run on continuous current circuits, and 2·0 to 2·2 watts per candle power for lamps on alternating currents. This difference is due to a peculiar action which alternating currents have on the molecular structure of the very fine-drawn tantalum wire.

Tungsten Lamps. The metal tungsten was discovered in 1780 by a Swedish chemist, Scheele, and derives its name from two Swedish words meaning heavy stone. Its fusing-point is about 3200° C., or nearly double that of platinum (which melts at about 1710° C.), and its specific gravity is 19·1. Pure tungsten rather volatilises than melts, and does this at a temperature equal to, if not higher than, that at which a carbon filament disintegrates. Till quite recently the metal was rare, but it is now commercially obtainable in the form of a black powder. It is very brittle, and the greatest difficulty has been experienced in making it into serviceable filaments.

Numerous processes are in practical use, many of them resulting in the production of what is termed a *squirted* filament. Either powdered tungsten or some salt of tungsten is mixed with a binding material and pressed through a small orifice, forming a squirted filament. This is afterwards heated electrically in an atmosphere of hydrogen, reducing the salt to the metallic state. The foreign matters in the filament are then volatilised, with the result that a very fragile, thin thread of pure tungsten is left. This is further heated and the metal gradually "sinters," or fuses together; but owing to its method of manufacture it always remains very fragile. Great care and innumerable experiments have resulted in lamps being made with filaments of this type with satisfactory results. They withstand severe handling, and manufacturers speak of losses in transit with latest types of lamps of only 3 per cent.; but for long the breakages of these lamps, coupled with their high price, greatly militated against their extensive adoption.



207. LIGHT DISTRIBUTION FROM SHADES IN 205 AND 206

The discovery of methods of making tungsten wire has done much to popularise these lamps. At first the metal was alloyed with such metals as cadmium or nickel to make it less brittle, and then drawn into wire which was subsequently heated electrically in hydrogen gas to drive off the easier volatile cadmium or nickel. The General Electric Company of America, in conjunction with

their English allies the British Thomson-Houston Company, have now worked out a method of drawing pure tungsten into wire, and an increasing proportion of the metal lamps in use is made by this process. Contrary to expectation, the exhaustion of a metal lamp has to be carried out more carefully than for carbon filament lamps. Mechanical pumps of a very special character, capable of giving a vacuum of 0·00001 mm., are used, and every care is taken to obtain the most perfect exhaustion.

Properties of Metal Lamps. Tungsten lamps, by reason of their high temperature when in use, are very efficient, the consumption often averaging only 1·5 watts per British candle power, over long periods. This, compared with the 3·5 and 4·0 watts per candle power of the carbon lamp, shows what saving in current can be effected by their use.

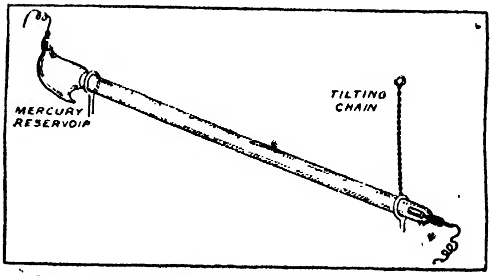
All metal lamps have filaments the resistances of which increase with the temperature. In this they differ from carbon filaments, the resistance of which falls as the temperature rises. Consequently metal lamps are much less susceptible to changes in the voltage of supply, and the useful life of the lamp is increased. For instance, three average lamps were very carefully tested. On starting they gave 22·6 candle power with a consumption of 1·32 watts per candle power. At the end of 6000 hours the candle power was 13·7 candle power, and the consumption 2·02 watts per candle power. A Tungsten lamp giving 16 candle power at 100 volts increases only to 18 candle power at 104 volts, while a corresponding carbon lamp would at 104 volts give 20 candle power.

The Nitrogen Lamp. An extremely efficient lamp has recently been introduced having a short, thick tungsten filament in a bulb containing nitrogen gas from which every trace of air and of water-vapour has been rigorously excluded. This permits of a higher temperature being maintained, and therefore the lamp gives more light in proportion to the power expended. These lamps are called "half-watt" lamps, because they give a light of about 200 candle power for an expenditure of 100 watts.

The Nernst Lamp. A lamp which for some years was very popular, but is now little used, is the Nernst lamp. The filament consisted of a short length of an infusible earth made of the oxides of several rare metals, of which zirconia is one. This filament, if previously brought to a high temperature, became a conductor of electricity and emitted a very brilliant light. Such lamps burnt in air, and were very suitable for high voltages, such as 200 to 300 volts. They had an efficiency of from 2 to 2½ watts per candle power, but in practice the trouble was to get them to light up. Great ingenuity was shown in devising automatic heaters, and the final form was very successful. With the advent of the high voltage metal lamp the Nernst burner fell into disuse.

Mercury Vapour Lamps. These lamps have more than passing interest, because it is possible that the lamp of the future will be of the vapour type, dispensing altogether with the incandescent filament. Mercury vapour lamps are generally known as Cooper-Hewitt lamps [208], though other types are in use. They are only suitable for direct currents. A transparent tube, sometimes made of quartz, sometimes of glass, and about 22 inches long, is partially exhausted, and a small quantity of mercury is placed in the upper part. Electrodes are placed at each end of the tube, and on starting the lamp is tilted so that the mercury momentarily connects the two electrodes. As soon as this takes place the tube is immediately filled with an incandescent mass of mercury vapour, which continues even though the continuity through the mercury is broken.

This vapour is very rich in violet and deficient in red rays, so that, although it is very useful for



208. THE HEWITT MERCURY VAPOUR LAMP

many purposes, its effect on the human skin is to give an appearance of great pallor. The light, however, is very restful, and enables the finest work to be done for long periods without injury or exhaustion to the eye. This gives it great favour in drawing-offices.

The Moore Lamp. The Moore is another type of vapour lamp which promises well. A glass tube about 1¾ inch diameter is taken in long lengths round the room to be illuminated, generally suspended near the ceiling. The length of the tube may be anything up to 200 feet. The tube is filled with nitrogen gas and exhausted to about $\frac{1}{10}$ inch. Small carbon electrodes are placed in the ends of the tube, which are connected to the terminals of a small alternating current transformer giving 10,000 to 12,000 volts. On turning on the current the tube is filled with a reddish light very pleasing to the eye. To maintain the vacuum constant a very ingenious valve is fitted to the tube.

Illumination. The next step in electric lighting is to learn how properly to utilise the light produced by various lamps. Some of them, notably the metal lamp, have so high an intrinsic brilliancy that unshaded they are positively injurious to the eye. It is possible, however, by the use of suitably cut shades and reflectors to direct light rays as one will and to concentrate or diffuse them to suit the conditions of use. The Holophane Company's shades are specially designed with this end in view. What can be done is shown in 207, which gives the light distribution curves for the two shades in 205 and 206. SILVANUS P. THOMPSON

Function and Balance of the Bow. How Effects of Light and Shade are Obtained. Advantages of Combined Playing. Methods and Examinations.

VIOLIN BOWING

From the foregoing remarks it should be evident that the violinist's left hand has a very important office. All the finger technique which a keyboard player has to master with both hands, in the violinist devolves on his left hand alone. As the majority of human beings are right-handed rather than left-handed, we have hitherto treated specially of the manner in which the less exercised member is employed.

The Hands. Not only does accurate intonation depend on the way in which the left fingers stop the notes, but the quality of the tone is influenced by the manner in which the digits move, and the rapidity of such motions is the first necessity for velocity in execution. Moreover, D'Arpentigny, in his interesting book on "La Science de la Main," draws attention to the fact that the most correct and thorough musicians are characterised by having what are known as spatulate fingers, such as are numerous amongst mathematicians and algebraists, strict observance of time and measure being the necessarily precedent condition of musical rhythm. Musicians, then, whose finger-tips are spade-like in shape, are generally those who can play in time most accurately. On the other hand, the same authority shows that melody is the peculiar province of fingers which are pointed. Such are less reliable in an orchestra, although they are more capable of taking the world by storm in solo work. Where both forms are combined, as was the case with Paganini and Liszt, executive musical powers appear to reach their culmination.

Should the student, then, possess thick, square-ended fingers, he will, as a rule, find it wise to give more attention to the cultivation of melody and expression in playing, than if he has fine-pointed fingers, in which case, his chief care should be accuracy in time, as playing in tune will come more naturally to him. Be that as it may, correct movements of the right hand are as essential to the violinist as those of his left, for the right hand manipulates the bow. Without it the violin makes no musical appeal, inasmuch as the right hand and arm movements supply the necessary mechanism for the production of the tone, just as the keys, levers, and other parts of the complicated double escapement, check and hammer action do in the pianoforte.

Nuances. If the left hand of the violinist is indispensable for the production of tone, semitones, intervals and nodes, it is the right hand of the player which furnishes not alone the vibration, but the *piano*, *dolce*, *forte*, *fortissimo*, *smorzando*, *diminuendo*, *calando*, and all the other subtle shades or nuances which go to make up expression in playing. The student should understand that the development of tone-quality is something infinitely more than mere loudness or softness. Accuracy of fingering may be the first essential, but unless this is allied to skill in bowing, the result is colourless and uninteresting. A graceful and effective handling of the fiddle-bow is a fine art. The bow represents more to the violinist than do the keys to the pianist. When well managed it is the fiddler's loud and soft pedal. It acts also in the capacity of the swell shutters of an organ.

But whereas pedal effects are produced mechanically on a keyboard instrument, the violin student must train his right hand and arm to furnish the mechanism, and before he can use the bow with dexterity, long and careful practice is indispensable. But a charm of the violin and its bow is that the two invariably reward merit and show no consideration for persons. Thus, the needy but good player with a cheap fiddle and cheap bow, who by practice has made himself expert, will obtain a better effect than the bad player, although he possess a priceless Strad.

Function of the Bow. Neat execution in violin playing is only possible by adroit bowing. An orator may have a good voice, just as a fiddler's left hand may give correct intonation; but it is the speaker's knowledge of the art of delivery which influences and stirs up the emotions of his audience. Hitherto the student, if he has followed the directions given, has endeavoured to bow with regularity and straightness of direction—we have not confused him by describing the many varieties of expression obtainable by the right hand. It is now impossible for him to give too much attention to the different styles of bowing. For these he will find that sometimes the whole bow is used, and at others the half bow; and that the lower, the middle, and the upper parts of the bow each have their duties.

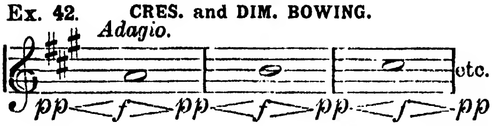
Open Strings. The student should endeavour to infuse light and shade into the four open notes by varying the side-pressure of the bow as they are played. To get the most delicate softness of expression, which was such a charm in the playing of the great Paganini, the straightness of the bow may now slightly be departed from. For ordinary purposes the stroke of the bow should be midway between the end of the fingerboard and the bridge. But the softest effect is obtained when the bowing is done close to the end of the fingerboard, whilst the sound is most brilliant when the bow approaches the bridge firmly.

Now begin at the tip slowly. Put the point loosely on the string, lower down than usual. Push the bow upwards, increasing both the pressure and the speed as well as the direction, in order to get a uniform crescendo. The stroke should be so regulated that it has its maximum firmness as the hair approaches most closely to the bridge. This should be when the middle of the bow passes over the string. Then, continuing the motion, cause the sound to diminish in the same way by small degrees, so that when the nut of the bow reaches the string the tone is almost inaudible.

Simple as this exercise may appear, it needs considerable practice to do well. In lessening the pressure and rapidity of the stroke, the player aids the effect by imperceptibly elevating the bow whilst he moves it further from the bridge. To do this skilfully requires flexibility of wrist, so that the entire weight of the bow never presses down vertically on the string. Now try Ex. 42. Practise the effect with the down-bow on each note of the scale, placing the nut of the bow very delicately on the string nearer the fingerboard than usual. Bring the bow down with increasing strength and a backward movement of the arm, so that the speed is greatest at the middle, when the hair is closest to the bridge. Power over the bow, it will be perceived, is mainly produced by the thumb, forefinger, and wrist. It is only when the bow approaches the bridge that its weight is sustained principally by the little finger. This relaxes its tension naturally as the bow descends.

Legato. A curved line in the music, which links two or more notes together, indicates that all must be played with the same stroke of the bow. The notes being tied together, the manner in which they are played is known by the Italian word *Legato.* Bend the wrist carefully on approaching the bridge. The longer a note is sustained, the greater, as a rule, is the length of bow used. Therefore, begin a long slurred passage either close to the tip or the nut [Ex. 43].

Ex. 42. CRES. and DIM. BOWING.



Legato playing is a very important branch of execution for the learner to acquire. It is a fine art to make the sounds of the string flow continuously, so that whether the bow is at its heel or tip, or is changing the stroke, the effect produced is equal. Without regular practice, the most naturally gifted violinists have not acquired the ability to bow smoothly, and thus compensate for casual lack of strength in the left hand, or subdue spasmodic exhibitions of unusual digital power. When Opie was asked how he mixed his colours, he replied, "With brains." Any great violinist when questioned how he contrives to bow so gracefully can give the same answer. Not alone the hands, but brains must be employed if the learner is to make progress. After lengthy practice it often happens that the conscientious student perceives that he is playing worse instead of better. He should feel encouraged by such a belief instead of being disheartened. Unknown to himself, he has raised his own standard of musical appreciation, and is aiming higher than he did at first. He is beginning to be a true artist, and the greater the excellence to which he attains the more will he in secret feel dissatisfied with himself.

Balance of the Bow. Apart from sustaining the tone with different degrees of strength, the bow, as the source of expression, gives to violin music its accent. Slurs of moderate length are begun about the middle, where quick, full notes are generally played with the last quarter of the bow. After first seeing that the hair is clean, practise short, quick slurs in order to improve the balance of the bow. The weight of the two ends of the stick being unequal, the wrist of the player must accustom itself to neutralise this inequality, and place the bow on the strings at any given point at the right angle so that the bow is in a constant state of equipoise, ready to do whatever is required of it with the least effort. To get balance of the bow, play from the nut, using, at most, 3 in. of the hair for each slur. Grasp the stick almost rigidly with all the fingers. Do not take the bow off the strings nor the fingers from the stick. The pressure of the hair on the strings should be light, and the notes should flow evenly and be neither hard nor harsh.

Ex. 43. LEGATO BOWING

Ex. 44. DETACHÉ BOWING

Ex. 45. PUNTATO BOWING

Ex. 46. STACCATO

Ex. 47. MARTELÉ

The *detaché*, or separated, style of bowing is used when a short, emphatic note and its successors are played firmly with equal power and duration. Keep the elbow perfectly still and the back of the arm steady. Make the strokes as long as possible. To produce equality, put a little more vigour in the up than in the down bows [Ex. 44].

Puntato. Not only is richness of expression gained, but interest is added by studying the same exercise, bowing it in a different way. What is known as *puntato*, or pointed, bowing is the firm playing of dotted notes with the tip, keeping the bow on the strings. For strengthening the right wrist, Ex. 45 will be found an excellent drill.

Very like puntato, only more separated, is the opposite style of bowing to legato. This is called *staccato*, one of the most brilliant, bright, and beautiful of bowings. The thumb should now press the stick lightly. Start the series of detached notes, or chips of sound, from the tip in an up-bow, or the middle of a down-bow. The latter is the more difficult. In the former, the upper half of the bow is always used. With one stroke the disjoined percussive notes must be articulated clearly, smartly, and in strict time. Such notes are marked in music by dashes or dots above or below them.

Nothing but intelligent practice will lead to a mastery of rapid staccato bowing. No unbowed instrument is capable of giving the peculiar staccato effects which can be made by skilled players of the fiddle tribe. Although the production of this feature is purely mechanical, and some performers show an exceptional faculty for its accomplishment, others fail to properly acquire the knack. Imagine the hair of the bow to represent a 2-ft. rule marked vertically with sixteenth divisions of an inch. In playing a passage of notes staccato, endeavour to employ only one of these sections for sounding each note. Begin slowly. After each short thrust, stop. Never go backwards and forwards; let the stroke always advance. Good staccato players can execute long passages softly, articulating each note clearly without the bow having visibly crossed the strings any distance. The reason why the staccato is easier to do with the upper than the lower half of the bow is because, in the latter case, the weight above is liable to make the bow spring and take away from the firmness and dryness of the effect [Ex. 46].

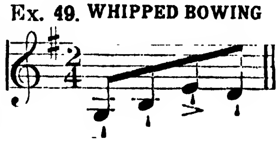
Changing the Stroke. When the length of the bow does not suffice to execute a note or notes within the time indicated, the change of stroke must always be done very smoothly with no diminution of power, so that no interruption may be heard if in the middle or towards the end of a passage.

This style, known also as the *Martellato*, means "hammered." It consists in detaching notes from each other with the upper part of one bow, causing the hair to dwell for a moment on the string so as to damp the sound instantly and give the effect of a little knock. If, after a special direction like "Martelé," the word "segue" occurs in the music, it implies that the preceding

Ex. 48.

style of bowing is to be resumed, or literally "followed" [Ex. 47].

Ex. 49. WHIPPED BOWING



Tremolando. *Tremolando* implies a shivering or wavering tonal effect. It is indicated by a short waved line under a long note or chord. Tremolando is executed by the note being bowed with a loose wrist and considerable rapidity. The arm must be free and the little finger lifted. Necessary pressure to make the bow bite, but without exaggeration, is supplied by the second and first fingers together with the thumb. There are three kinds of tremolando bowings. The first is a prolonged shiver on one note. The second is a rapid arpeggio over two strings, the first note being followed by a second thrice reiterated. The third variety is when one note is followed by a second repeated thrice as before and ends with the first note, the last three sounds of the group being taken twice as fast as the first two.

Begin in each case with a sharp jerk of the wrist, as if shaking drops of water off a wet hand. This gives the impetus for the spring of the bow and the recoil stroke, the motion of the right hand for tremolando bowing being ellipsoidal instead of straight down and up [Ex. 48].

Fouetté. *Fouetté*, or whipped, bowing is done by the bow being lifted off the string and thrown on it sharply with an up-stroke near the point so that it does not tremble [Ex. 49].

Arpeggio Bowing. This means in the style of a harp. Some old writers spelt the word "harpeggio." In arpeggios on all the four strings of the fiddle the first care must be to get correct intonation. The more awkward the fingering the greater must be the attention paid to getting each note in tune. If the student tires during this study, he should turn to something easier. The effect should be a series of soft percussive pulsations, the elasticity of the bow causing it to bound easily from string to string. Begin by slurring the note on the four strings before attempting to make the bow dance. The knack will come gradually. At first the bow will have a habit of dancing two or three times on the same string. With

practice this irregularity will be cured. Never exaggerate the dancing. Make it quietly. Remember that arpeggio notes should be played consecutively with a smooth, harp-like effect. The middle of the bow is used mostly for four-string arpeggios. Keep the hair flat on the strings and the stick more to the left than usual. Ex. 50 gives three bars from an excellent study by Spohr.

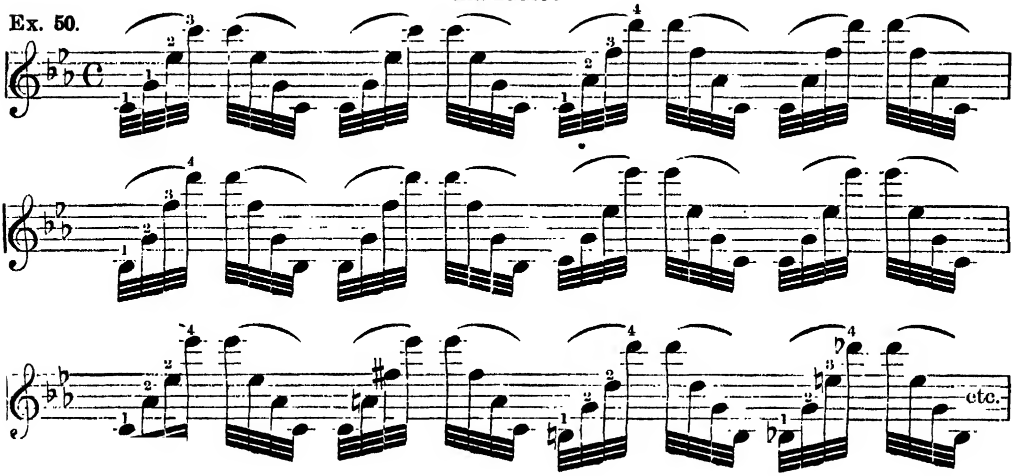
Saltato. *Saltato,* or sautillé, is a peculiar staccato effect obtained by making the bow bound and rebound on a string quickly, or whilst see-sawing across the strings as in extended arpeggios; but the effect is more "jumpy" than before. First tighten the bow. When the faculty has been acquired, the degree of force used can be varied. Keep the tip of the little finger rigidly on the stick. Relax the other fingers. Hold the bow half an inch above the string—the part of the bow used is the middle. Drop it in such a manner that the hair shifts a fraction of an inch and the note is bowed as well as struck. The natural recoil brings the bow back for the next hop. Now try tripping on the strings, steadily increasing the height from which the bow falls; but the stick must not be allowed to strike the strings through the hair [Ex. 51].

Col Legno. *Col Legno,* as the Italians say, means "with the wood," or *Le Dos de l'Archet,* as the French say, means "with the back of the bow." Wagner, Boildieu, Liszt, Strauss, and other composers, have made use of this effect to produce weirdness in orchestral colouring. When the words occur, the player simply turns his bow over and makes the wood chatter on the strings, or scrapes them as directed. The effect is rarely employed, and the student need not trouble about it.

Pizzicato. *Pizzicato* for the right hand is of far more importance. The term implies that the strings are pinched or plucked so as to give a guitar effect; meanwhile the right hand holds the bow firmly near the nut by the last three right fingers. There are two ways of executing right-hand pizzicatos. First, when the passage is a short one, the violin remains under the chin. Place the tip of the right thumb against the lower edge of the fingerboard. With the first finger, pluck the string or strings until the words "col arco" occur in the music and the bow is again used. The second way of making pizzicato is employed when the passage is a long one. It is then more convenient and productive of a fuller tone to hold the violin like a guitar. Retain the bow in the right hand as before. This time put the first finger against the edge of the fingerboard. Do the plucking with the thumb. Keep the nails short; if they are long, not only is the tone bad, but the strings are liable to be cut.

ARPEGGIOS

Ex. 50.



Ex. 51.

Mind Training. Let us repeat that all bowings must be practised slowly at first and with great care. Mark Hambourg says that "it is as important to train the mind as the fingers if one would be a great instrumentalist," and he further remarks that unless the whole heart and soul of a pianist is working with his fingers, he may as well leave the piano alone. This observation applies even more to the violinist, who supplies the mechanism of his own instrument. As the student becomes familiar with the correct ways of bowing, speed can be increased.

Before a violinist can co-operate usefully and successfully with other players, he should have reached a fair stage of individual proficiency. First, he ought to be able to play in tune;

next, by reasonable mastery of the bow, he should be able to express the shades of tone marked in the music; and, last but not least, he must have the faculty of keeping time so that he does not hurry over easy passages nor "drag" during difficulties. Unqualified fiddlers are the ruin of most amateur orchestras. Professor Prout, echoing Schumann, has said that "Bach's 48 Preludes and Fugues should become the daily bread of the pianist." In like manner, Kreutzer's 40 delightful studies should be the diurnal diet of the violinist. They can be purchased for 1s. 6d. from Boosey. In most towns nowadays there are amateur orchestral societies, or choirs accompanied instrumentally. As soon as possible the student should seek election as a second violinist in such a body.

Advantages of Playing with Others. The experience gained by the student who does this will teach him much that cannot be appreciated during solitary practice. First, playing with others will train him to read at sight. Secondly, it will open up to his mind a large province of good music hitherto unexplored by him. Thirdly, if the conductor knows his work and the orchestra is competent to follow his directions, the student who is familiar with some well-known composition will learn how a different complexion may be given to it by a distinctive manner of "reading." Fourthly, what is known as syncopated playing, or altering the rhythm by driving the accent to that part of a bar not usually accented, is often more easily acquired in association with others than when bowing alone. Fifthly, the student, especially at concerts, will have an opportunity of gaining valuable hints from artists engaged who are better players than himself. Sixthly, he will thereby, if he keep his ears and eyes open, be able to correct shortcomings in his own playing, and so develop his natural gifts whilst avoiding undesirable mannerisms in others.

Family Intercourse. The violin student's purest enjoyment, however, will probably be found as soon as he is capable of taking part in a stringed quartet or quintet. Wonderful as his instrument is by itself, or when played in unison with other fiddles in an orchestra, it is related by the closest of family ties to a set of larger instrumental brethren, all equally remarkable in their way. These extend the compass downwards. During harmonious intercourse with its kindred, therefore, the first violin is representative of the soprano voice, the second violin of the contralto, the viola of the tenor, the violoncello of the bass, and the double bass of the basso profondo in a quintet, outrivalling in height and depth of tone that of the contrasting hum . voices.

To excel as a soloist on the concert platform, a mastery of the most complicated difficulties is demanded nowadays. Although, unlike the pianoforte, the violin attained its highest mechanical development long ago, there seems to be no end to the way in which records of skill and virtuosity are beaten by one player after another. Parents have often wished that their children might have old heads on young shoulders. That miracle has frequently happened of late as regards violin playing. Extraordinary executive perplexities are overcome with ease by many a child-prodigy. Mischa Elman as a little boy—to say nothing of Max Darewski—and the girl Vivien Chartres revealed in public a matured insight into the meanings of advanced compositions for this instrument. In such cases the child has usually been brought up in a musical atmosphere. Unconsciously, good music has been nourishing the mind as bread or meat have been building up the body. If, therefore, the self-instructor desires to excel on the violin, we cannot add better advice than this: "Do not fritter away time. Economise it. There is much to be done, and life is short. To make rapid progress, the student should take every opportunity of associating with better players than himself. Go as often to concerts as possible. If not good enough to play second fiddle in an orchestral society, volunteer to help the librarian or steward to put out the music." By keeping his ears open, the student will then find himself in a position to hear much to help and stimulate his practice.

Books. Of books calculated to enthuse the lover of the violin, sometimes obtainable cheaply secondhand, we may mention "Famous Violinists," by Henry Lahee; "How to Study the Violin" by Hans Wessely, and "The Violin and its Makers," by Antonio Stradivarius; "The Violin," by Dubourg; "The Bow: Its History, Manufacture, and Use," by H. Saint-George; and that delightful work "The Violin: Its Famous Makers and Their Imitators," by George Hart.

Methods. The most notable methods are those of Wilhelmj, Joachim, and Sevcik, as used at the Paris Conservatoire; and the tutors by Kreutzer, Rode, Firrillo, Dancla, David, and Hermann—soiled copies of which are frequently procurable from the secondhand bookshops which abound in Charing Cross Road, London, at a nominal price.

Examinations. A sure way of testing progress and ascertaining that the student is on the right road is to work up for the graded examinations of the Incorporated Society of Musicians. Write to 19, Berners Street, London, W., for particulars. These tests are held periodically in all the chief centres of Great Britain and Ireland. The examinations are in four classes, the maximum of marks given being 100 in each grade. In the easiest class, the marks are allotted as follows: Scales, 12; Arpeggios, 8; a Study, 15; a Piece, 40; Sight-reading, 10; Questions, 10; and Ear-tests, 5. The points which are particularly considered by the examiners are correctness of intonation, strictness of time, the fingering employed, the phrasing and accentuation, the attitude of the player, and the manner of his bowing.

The compass of all the different members of this important musical family is given in the article on ORCHESTRATION.

ALGERNON ROSE

Cleaning, Winding, Throwing, Sizing, Drawing, and Spinning Silk. Removing the Gum. The Treatment of Silk Waste.

SILK THROWING AND SPINNING

The methods by which the so-called raw silk is made from the cocoons by silk-reelers in the silk-producing countries have been explained in Chapter 7, page 897. It remains now to follow the course of the raw silk through the machines of the silk-throwing factory. We have seen that raw silk arrives in the form of *slips*, or skeins, made by drawing off fibre from the cocoon and winding threads from several cocoons over the arms of a hexagonal reel. The first measure is to take these slips, open them, straighten them, and, if need be, divide them into smaller skeins of approximately equal lengths suitable for the *swifts* upon which they have to be placed to be re-wound. A girl does the work, and she passes the slip over two upright rotating barrels or bobbins. By rotating the slip its threads are opened out, and they lie flat, much as they did upon the original reel. In this condition the hank is easily divided into portions, loose ends can be detected and tied, and conspicuously bad places can be removed.

Soaping. Well-reeled silk can be treated *bright*, or, in other words, without soap, but to facilitate working the silk it is most often steeped in a more or less strong solution of soap and hot water. From 4 to 8 per cent. of soap is deposited upon the fibre; and as good white curd soap does not injure the silk, and as the soap all comes away along with the natural silk gum when the silk is *boiled off*, the practice is unobjectionable.

The use of bad soap and of hard water, and still more the use of insoluble chemicals which are employed solely to add fictitious weight, are to be deprecated. After the silk has soaked for a sufficient length of time the skeins are wrung out by hand, put into the cage of a centrifugal drier to expel the main part of their water, and their drying is completed either by hanging them in air or in the heat of a stove.

Winding and Cleaning. The silk has then to be run on to bobbins [see page 901], and the skeins are spread over the arms of revolving swifts. The end is found and led through a guide which is given a side-to-side motion so that the silk is spread evenly and without any appreciable friction upon a wooden bobbin placed horizontally upon the winding frame. Means are taken at the same time to *clear* the silk of husk, knots, or other projecting irregularities by passing the end through a narrow cleft between two parallel steel plates, or otherwise through slots in single steel plates. In the event of the stoppage of the thread, the bobbin is automatically stopped until the attendant has freed the tangle. These stoppages for repair are extremely frequent in winding *tsatlees* (or hand-reeled Chinese raws), and comparatively infrequent in treating the best Italian and French raw silk. Thus a much greater quantity of the French raw silk can be dealt with in one day.

Tram and Organzine. The winding of the single-thread raw silk on to bobbins is the preliminary to the throwing or spinning by which a number of these single threads are joined into one finished thread and are bound together by being twisted. The degree of twisting varies with the purpose for which the yarn is to be used. The *no-throw* silk, made at Derby for braid-making, is given virtually no twisting at all. The *tram* silks which are used for weft are composed of two or more single strands to which no twist is imparted by the throwster, but the tram is given two or three turns to the inch in the act of doubling. *Organzine* silk, or warp, is twisted in the single and in the doubled state.

No-throw and tram are as bulky and flossy as the throwster can safely make them, and organzine is made hard and strong because it has to support the tension and friction of the loom. Hard twisting alters the character of the silk, and it is resorted to for other purposes than weaving, as, for example, in making some knitted scarves, surgical elastic stockings, and the best sewing silk.

Silk Throwing. The throwster's spinning frame is arranged usually in two tiers in the interests of the economy of space. It transfers silk from the winder's bobbin—or from more than one bobbin—on to the spinning bobbin. The latter is driven by a band of cotton twine, which derives motion from a relatively large tin cylinder, and communicates it to a comparatively small whorl. Above the bobbin a light wire flyer is mounted, and the relative speeds of the bobbin and the flyer determine the number of turns per inch given to the silk wound on.

After being thrown the silk is wound from the bobbin back into skeins, passing off the bobbin through the eye of a flyer and on to a hexagonal reel. The reel is given a quick, side-to-side motion by the action of cams, with the consequence that the yarn is laid upon its swifts diamond-wise. This *cross reeling,* or *Grant reeling,* as it is called when a very long traverse is given, assists to prevent the catching or entanglement of neighbouring threads, and thus facilitates their further handling.

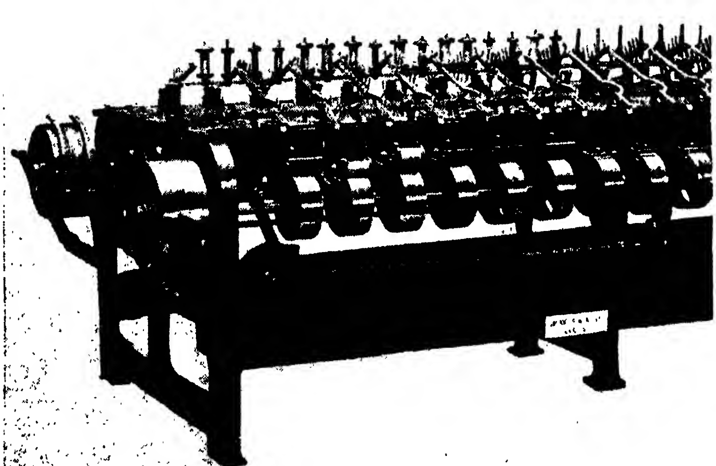
Sizing Silk. The silk is reeled into skeins of a determined length, usually of 1000–2000 yards. The importance of maintaining a uniform length is seen when it becomes necessary to classify the skeins according to their fineness. There are wide differences in the fineness of raw silk of one origin, and the mixture of these skeins together occasions perceptible differences or faults in the

manufactured goods. When skeins are of the same length, the difference of fineness can be detected by weighing. The *drammers*, or sizers, assort the skeins according to the weights. A simple spring balance terminating with a hook is hung before each of these girls, the weight of the skein is read in drams, and those of similar fineness are placed together. The skeins are put together to form larger skeins or hanks, and the hanks are tied together to form bundles.

Conditioning. Silk material is valuable, and such as we have described is worth normally from 15s. to 25s. per pound. Precautions are therefore taken in the factory against the stealing of silk. In buying silk there is a preference for buying it *conditioned* with the certificate of a public Conditioning House. Like wool and cotton, silk takes up moisture from its surroundings, and in standard condition silk weighs 11 per cent. more than it does when reduced to absolute dryness by the heat of the conditioning oven.

Waste Spinning. We have seen [page 899] that the manipulation of cocoon silk and raw silk involves the production of silk waste of a kind capable of excellent service, but not utilisable in the form of a continuous thread. The manufacture of *spun* silk from discontinuous fibre is a considerably more important industry in England than that of making *net*, *neat*, or thrown silk. In making spun silk the procedure follows the same broad lines as in spinning worsted or cotton, although there are some essential modifications.

Discharging the Gum. After receiving, weighing, opening, and blending his waste silk, the English manufacturer proceeds to *discharge*, or boil off, the silk gum in such a manner as to get rid of it thoroughly and to have a clean mass of soft and supple fibre of good colour left behind. A wooden cistern, fitted with a perforated false floor, is used. Water is laid on to the tub from a pipe above, and



SILK CLEANING AND GASSING FRAME
From a photograph by courtesy of Messrs. Greenwood & Batley, Leeds

steam is passed into a coil below the false flooring, so that the water can be boiled. The water is brought to the boil, and a quantity of the finest white curd soap, equal to 10 or 12 per cent. of the weight of the silk to be treated, is cut into shavings and thrown in and dissolved. Silk is never entered into boiling water, as this has the effect of fixing any defects of colour, and the bath is cooled to about 180° F. before the silk is thrown in. The waste is opened out into a loose condition and placed in quantities of about three-quarters of a pound in little, open-meshed canvas bags, securely tied at the neck. Steam is laid on, and the silk is boiled for about two hours, the bags meantime being turned and changed in position in the vat.

When the gum and dirt have been sufficiently loosened, the silk is passed through mangle rollers to squeeze out the excess of moisture. It is then given a second boiling for a rather shorter time, but with a somewhat stronger solution of soap, to remove the impurities loosened in the first operation, and after mangling or centrifugal drying the material is further dried by steam or stove heat. It is necessary that the drying should be even throughout the whole mass, and the best results are got from the careful use of travelling lattice machines, so arranged that the silk is carried in a thin and uniform layer slowly over steam-pipes. The machines are in tiers, and the silk, after travelling the length of the machine, falls upon another creeping lattice and is carried back. At the end of this traverse the material falls upon a third lattice, to be conveyed ultimately into the air.

Loss of Weight in Boiling. The loss of weight in boiling off is considerable, being from 30 to 40 per cent. upon the classes of waste most used in England. A portion of this loss is recovered when the ultra-dry material has lain for a term in the air to regain its natural amount of moisture, or after it has been allowed to lie in a damp place. Silk in an unnaturally dry condition is incapable of manufacturing treatment, because the fibres become electrified and stand off from each other, and so escape the teeth of the combs and gills that are used to lay them parallel.

Schappe Silk. The *schappe* process of removing the silk gum more or less thoroughly, but not completely, is practised largely upon the Continent. The silk waste or cocoons are placed in the inner compartment of a wooden cistern. This compartment is perforated upon its sides and bottom to admit water from the outer chamber. When a certain quantity of silk has been laid in, the mass is allowed time to become fully saturated, and then another quantity is added. The procedure is continued until the cage is full, when a lid is laid on the top and weighted down. Steam is admitted into the outer compartment, and the whole is kept at a temperature of about 140° F. for a period of some days. Fermentation sets in, acrid ammoniacal odours are generated, and the gum decomposes. When the decomposition is judged to have gone far enough, the material is taken out and thoroughly washed.

The washing calls for large quantities of soft water, and the process is worked to the greatest advantage by mills upon both sides of the Alps, which are favoured with unlimited and free supplies of glacier water. In washing, the spoilt cocoons

and waste are macerated by stamping machinery. The material is carried round continuously upon a revolving pan, and thus beneath the stamps which squeeze the water through and through.

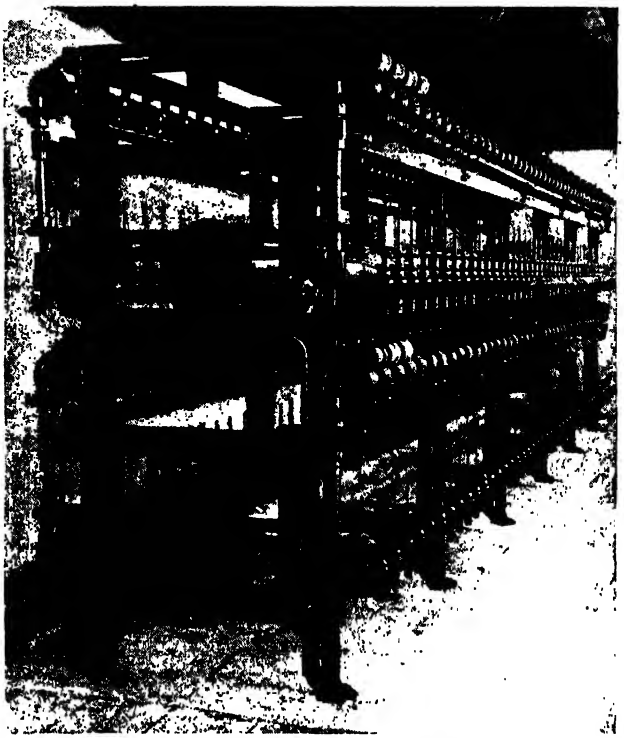
Fibres of schappe silk derive a certain stiffness from the gum left behind, and this facilitates their treatment on machine combs upon which fully discharged silk waste cannot be worked to any effect. The amount of gum left in schappe silk ranges from as little as 2 per cent., when its presence is barely perceptible, up to 25 per cent. or so, when the yarn is usually dark coloured and malodorous.

Preparing Silk Waste. In English spinning mills the boiled-off waste is placed upon the travelling apron of the *opening* machine, in which the fibre receives its first straightening treatment. The apron is furnished with bent steel teeth, with their points upward, and above this is a similar but shorter apron, with teeth pointing downward. These *porcupine* sheets pull and straighten the disordered fibres and carry them forward. As soon as the fibres project over the end of the aprons they are caught by the teeth of a swiftly revolving drum and are drawn round its circumference. Dust is liberated, and is drawn away by fan suction; and such hard-knotted pieces of silk as do not yield to the opening action of the teeth are detached and fall into a compartment below. The drum, in course of a little time, becomes covered, and when sufficient has been accumulated a cut is made across the width of the drum, and the loosened end is led through the nip of a pair of stripping rollers, and the whole lap is thus removed.

The Filling Engine. Silk waste is composed of fibres of widely varying length. Some of them may be yards long, and others are broken, perhaps, to less than an inch. It is necessary to reduce the longest fibres to a length suitable for spinning, and this is done upon the *filling engine*. The lap from the opener is passed between the toothed feeding rollers of the filling engine, and the ends of the lap are worked on by the steel teeth of a cylinder like that of the opening machine, except that the teeth are set in rows. These rows are from four to nine inches apart; and when a sufficient quantity of silk has been wound round the drum, the fibre is cut at each row with a knife or scissors, and the silk is left in a series of fringes upon the teeth of the filling engine. By this time the individual fibres have been laid in approximately parallel position; none of them is too long for the spinning machinery employed, and the next step is to *dress*, or comb, them to remove the shorter lengths.

Dressing Silk Waste. The fringes of silk are detached from the hooks of the filling engine by the aid of hinged boards folding together like the covers of a book. The board is brought to the circumference of the cylinder, and, by the use of a gauge, the silk is gripped between the upper and the lower halves so that half the fringe is held and half projects and can be combed. These dressers' boards are then lifted into the *inframe* of the dressing frame. They are set upright, with their fringe of silk protruding, wooden divisions are inserted between each pair of boards, and they are carefully levelled. The whole is then locked tight, and the inframe, which is really a sort of table, is swung into place for dressing to begin.

The dressing is done by rows of bent steel combs, bolted to an endless web of hemp canvas and tilted to a slight angle with their foundation. The webbing is carried round by the rotation of the rollers on which it is stretched; the inframe is gradually raised so that the points of the combs engage with the fringes of silk, and in passing they carry off tufts of fibre.



ORGANZINE SPINNING FRAME
From a photograph by courtesy of Enoch Rushton & Sons, Macclesfield

These tufts of fibre are subsequently stripped either by being nipped between bookboards or by being caught upon the teeth of a revolving drum. After a while the position of the inframe is reversed, end for end, so that the fringes are combed in both directions. When the protruding fringe has been fully dressed the boards are opened, and the ends which have been hitherto nipped between the boards are presented to the comb. The longest silk remains, held by the boards, and this is the quality spoken of as *first drafts*. The tufts stripped from the combs are dressed upon a second frame, and from them are produced the *second drafts*.

The process which we have described in some detail is repeated up to six times in all. The fifth and sixth drafts are called *shorts*, and are not suitable for spinning with long material in the manner of worsted, but are eligible for spinning upon cotton machinery. The residue left after taking out the several drafts is silk *noil*, a material that can be combed upon machines like those used for combing cotton.

Some three or four ounces of drafts are all that are obtained from each pair of boards, and this small production requires an amount of manual labour which contrasts strongly with the operation of combing wool. Fully discharged waste silk can be dressed upon circular frames in which the dressers' boards are locked around the rim of a cylinder, and the combing is done by toothed rollers. Waste silk, however, is so expensive that the gain in time and labour derived from the use of more rapid machinery does not compensate for the loss in the yield of longer drafts. Attempts to use wool-combs and cotton-combs for long-fibred silk have failed, because the combing pins do not obtain a sufficient purchase upon so smooth and soft a fibre.

Silk Spreading. The drafts have now to be converted from their fringe form into a continuous sliver, so they are rolled up carefully in tissue paper, and the little parcels of a few ounces each are brought to the *spreading machine.* The machine is a gill box of the type fully described in connection with the worsted process [page 2347]. The spreading is done by hand upon the feeding apron of the machine by a girl who picks up the fringe silk in small and uniform quantities and builds up a continuous lap by depositing the pieces of fringe so that they overlap to a regular extent. The material passes into the gill box, is straightened by the action of the travelling steel teeth of the gill fallers, and on coming out of the delivery rollers the lap is wound around a drum.

It then goes into the *sett frame*, another gill box in which the lap is drawn or drafted by the action of rollers, and it is delivered from thence in a continuous sliver. If the spreading has been properly done the sliver should be free from obvious differences of thickness, but many operations have to be undergone further to ensure perfection of result and to intermix fully the different drafts that are used in the particular yarn. Spun silk yarns of the highest quality are made out of first or first and second drafts only, but in many cases the first, second, third, and fourth drafts are all blended together.

Silk Drawing. To secure perfect results the silk sliver is passed through a series of drawing boxes, of which there are normally four. Twelve heads of the sliver from the sett frame are put up at the first box, and they are drawn down to a single sliver of rather finer size than any of the original twelve. A dozen or so from the first box are passed into the second, and again drawn to a single and finer dimension; the operation is repeated at the third and at the *finisher box.*

Short silk shows a marked disposition to ride over the pins of ordinary gill fallers, so that, in dealing with the shorter drafts, an *intersector gill box* is used. In this machine there are two sets of gills intersecting each other, one travelling below the silk and one travelling above, with the result that a firm grip is maintained. From the drawing boxes the silk passes to the *roving frame*, in which, after being gilled and drawn, the sliver is wound upon large bobbins by flyer spindles. The slubbing from the roving frame is transferred to the *dandy roving frame*, and the material from two or three of its bobbins is reduced to the still finer dimensions of a roving, in which state the yarn is in a condition ready for spinning.

Spinning and Gassing. In the silk industry the *ring* spinning frame [page 1555] has largely ousted the *flyer* frame which is used mainly for spinning to coarse counts. In most cases the spun yarn must be *gassed* to singe off the short ends of fibre which conceal the natural lustre of spun silk. The yarn is run from one bobbin to another, passing in its course through a series of a dozen gas-jets; and, as the charred fibre needs to be cleared, the yarn is carried round a series of bars, and the burnt fluff is removed by friction. The charring darkens the colour, and accordingly the yarn is ordinarily washed, an operation that is carried out gently, in order to prevent new projections being brought out upon the surface.

Spinning Short Silk. The methods outlined are those by which long silk waste is spun, chiefly for the uses of the weaving trade in the manufacture of sealskin plushes and stripings, and also for knitting, lace-making, sewing, and embroidery. The *shorts* (drafts lower than the fourth) and the combings from silk noils, as well as waste that has been chopped into short lengths, are treated upon a smaller scale by a separate set of processes, akin to those used in spinning cotton. Waste designed for use in short spun yarn is sorted by hand, and its fibres are laid parallel upon an opening machine. The silk is dressed upon dressing frames of the kind already described, but the dressing is done "in the gum," before the silk has been discharged, and simply in order to remove impurities and very short fibres.

The dressed silk is cut by a machine like a chaff-cutter to a length of between one and two inches. It is put into small bags and boiled, and after being dried is placed upon a roller scutching machine and formed into laps. These laps are fed into carding machines of the flat-card type [page 1692] or into roller cards, and, after being condensed into a sliver, the carded silk goes forward to the slubbing, intermediate, and roving frames. In short, the silk is cut to the length of cotton and is treated like cotton. Spinning is done either upon mules or upon ring frames.

The shorts of the long spinning process and the longer fibres obtained from the long-spinners' noils are added to cut waste, and a cheaper yarn is made from this short material than from the long. The yarn is less lustrous and strong, but it is very even and supple, and can be spun to high numbers. It is economically advantageous that these mills for the consumption of short silk should exist and provide a market for that which the other spinners cannot use upon their own machines.

Noil Yarns. The noils discarded by both classes of silk-spinner are used for making coarser yarns and cloths than those which are usually identified with silk. In this country they are manufactured principally by makers of cloths for wiping oil from machinery and for ammunition bags. Silk has a strong affinity for oil, and is hence especially fit for the one purpose, and as it is non-inflammable it is peculiarly adapted for the other. Occasionally noils are used for stuffing beds. The noils embody impurities such as dried portions of the silkworm, pieces of leaf, and occasional foreign matter, as well as short and curled fibres. In making coarse fabrics, the noils are treated in the same way as woollen material upon woollen cards and mules, and the more select qualities are made into finer yarns useful for making a silk stripe in tweeds. The noils are sometimes blended and worked in conjunction with wool, and they are used also to make grotesque and fancy yarns with binding threads of cotton.

J. A. HUNTER

The Modification of Land Formation and Sea-level by Volcanic Influences. Chemical Action Underground.

EARTHQUAKE INFLUENCES

THE geological effects of earthquakes are chiefly of importance beneath the surface of the earth's crust. They give rise to those great breaks of continuity in the stratification of rocks which are known as *faults* [36], and which we consider in a later chapter. A fault is a dislocation in the rocks where the strata on one side have been suddenly raised to a higher level than those on the other, and, consequently, they do not appear to be continued in their true order. A seam of coal may thus appear to come to a sudden end, although, as a matter of fact, it can be found again by rising to a higher or descending to a lower level on the other side of the fault.

The existence of dislocations of this nature probably indicates that a more or less destructive earthquake once took place at a moment when the rocks could no longer resist the pressure brought upon them by the upper strata, and gave way. Sometimes, also, an earthquake gives rise to a permanent change of level in the surface of the country; this is especially of importance near the sea-coast. By very severe earthquakes it occasionally happens that a long line of shore may be raised three or four feet above its previous level. New land is thus won from the sea, or, on the other hand, many square miles may be submerged beneath the surface of the water.

Secular Movements. We are accustomed to think that an alteration in the level of the land is always due to some violent agency like that of an earthquake. But although such sudden changes are more picturesque and striking than those which go on silently and almost imperceptibly throughout the ages, it is to the latter that the changes in the conformation of the earth's surface are mainly due. The utmost that an earthquake can accomplish is to open a chasm in the ground, such as that which was filled up by the fabled devotion of the Roman hero, or that which more authentic history tells us to have been caused by the earthquake in the Neo Valley, in Japan, in 1891.

But the silent forces which are ever at work, raising the sea-bed here and lowering a whole continent there, are of far greater importance to the student of geology. If it were not for them, indeed, the whole surface of the earth would ultimately become a dead level, and perhaps be sunk beneath an inundation, in comparison with which that which Noah survived was a deluge of inconsiderable magnitude. The denuding forces which, as we discuss in the next chapter, are constantly at work planing down and polishing off the surfaces of the land would, in the long course of geological time, infallibly produce this result were they not counteracted by the slow movements of *upheaval* and *subsidence*.

Upheaval and Subsidence. There are countless evidences on every hand to show that an actual rise and fall of the earth's surface does take place. We think commonly of the sea as fluctuating, rising and falling, overflowing the land, and again returning and leaving its beaches high and dry. But the truth is that the sea, though unstable as water, is really a permanent and unchanging thing in comparison to the solid land. Looking at the history of the world with the trained eyes of the geologist, which are able to peer through the backward ages and read the story written on the rocks, we may indeed say with Tennyson :

There rolls the deep where stood the tree.
O earth, what changes hast thou seen !
There where the long street roars, hath been
The stillness of the central sea.

The hills are shadows, and they flow
From form to form, and nothing stands ;
They melt like mist, the solid lands,
Like clouds they shape themselves and go.

In these beautiful lines Tennyson has expressed a far-reaching geological fact. The sea and land have changed places again and again in the history of the earth.

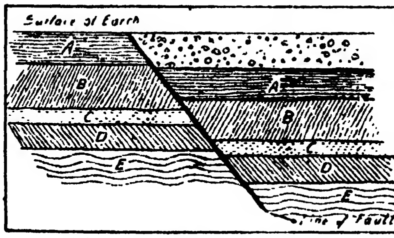
When we speak of the secular rise and fall of the sea, as distinguished from the periodical tidal changes, what we really mean is that not the sea but the land itself has sunk below or risen above its average level.

There are two ways, and only two, in which the permanent level of the sea may be changed —for an actual diminution of the actual bulk of its waters is not known to have occurred within historical times, and its probability may be left out of account. The land which borders the sea may be slowly raised, thus bringing more and more of the sloping beach out of the water ; or the sea-bed may sink, which obviously has the same effect, in causing the sea to retreat from the land. On the other hand, if the dry land subsides or if the sea-bed is raised, it is clear that in either case the result will be the same—an apparent rise in the level of the sea.

Changes in the Sea-level. There is visible to the most casual observer a great deal of evidence that the level of the sea has thus been actually changed during comparatively recent times. In the first place, we have the fact that the remains of organisms which can only live in sea-water are found as fossils in rocks which are at present high above the level of the sea. Thus in Cuba a coral reef has been found at a height of more than 1000 ft. above

the sea-level, which clearly shows that the land has there been elevated to at least that extent. A very striking instance is afforded by the pillars of a Roman temple in the Bay of Naples. When these pillars were erected, 2000 years ago, they stood, of course, on dry land. They stand on dry land now, but they are traversed by holes which were evidently burrowed by marine creatures at a time when they were covered by the sea to a depth of at least 20ft. Thus it is evident that since the beginning of the Christian era the land at that spot has first sunk and then risen several yards.

Puzzling Fossils. One of the problems which did most to perplex the early geologists was the occurrence of shells at considerable heights above the sea-level. The most grotesque hypotheses were put forward to account for this. Some held that the shells had been deposited there by pilgrims who used to wear scallop shells in honour of the saints whom they visited; others held that these shells represented the haunts of the primeval oyster-eater; others took refuge in the supposition that the shells were not really shells at all, but were *lusus naturæ*, or freaks with which Nature amused herself by imitating the products of the sea. We know now that wherever we see fossils of this kind they are simply a proof that the rock in which they are found at one time formed part of an ancient sea-bed.



36. DIAGRAM OF A FAULT

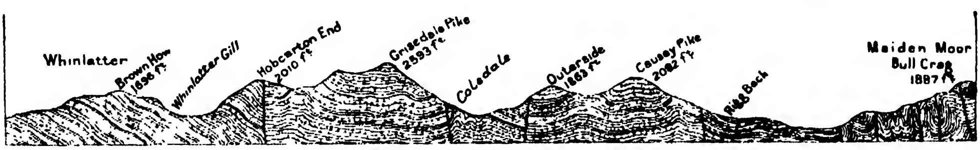
Raised Beaches. Another very interesting proof of the gradual elevation of the land is given by what are known as raised beaches. The sea-beach, or the space between the extremes of high and low water, is a very familiar and recognisable structure. It consists, as a rule, of sand or gravel, with which are mingled shells and other remains of marine organisms. In many parts of the country these unmistakable platforms are nowadays found raised high above the level of the sea. In many parts of Scotland, and on both sides of the English Channel, these raised beaches are to be seen. Alten Fjord, in Norway, is surrounded by a series of raised beaches—four or five terraces divided by intervals of many feet, which mark successive levels of the sea during quiescent intervals in the motion of the land, which, on the whole, has been steadily rising.

The so-called parallel roads of Glen Roy [38] are similar lacustrine beaches, which, however, owe their existence to an actual subsidence of the waters which formed them. As we gaze southward from the top of Reigate Hill over the district known as the Weald, it is easy to suppose that we are looking from the top of an ancient sea-cliff across what was formerly an arm of the English Channel, but which the gradual rising of the land has claimed for the work of human cultivation [40].

Where the Land has Sunk. Proofs that the land has sunk in some places as well as risen in others are not wanting. We do not refer to the mere eating away of the land by the sea, such as is occurring on the east coast of this country—this is due to erosion simply, and is dealt with in a subsequent chapter—but there are many places in which the remains of primeval forests are found submerged beneath the sea.

The existence of submarine coal-mines, such as are found off the east coast of Scotland, where the workings frequently extend far out beneath the sea, shows that the waters now roll over spots which were long ago covered with terrestrial vegetation.

Not infrequently, in boring through the crust of the earth, the remains of ancient forests are found, overlaid with deposits of sand and mud, and mingled with the fossiled remains of marine organisms which were evidently deposited by the sea. In making a new dock at Barry, on the Bristol Channel, clear proof was shown that the sea-level there had risen, or, in other words, the land had sunk, by more than 50 ft. The existence of coral reefs [see page 426] is asserted to afford another proof of the gradual subsidence



37. SECTION BETWEEN WHINLATTER AND MAIDEN MOOR, NEAR KESWICK, SHOWING WRINKLING
The black lines represent faults

of the land. The reef-building coral cannot live at a greater depth than about 150 ft. Yet in many cases the reefs which they build are found to rise out of water very much deeper than they could possibly inhabit, so far as we know. The obvious explanation of this fact is that the reef-builders began their work when the depth of water at this spot was not greater than 150 ft. As they build upward toward the surface, the sea-bed which served them as a base is supposed to be slowly subsiding, so that their unwearied labour is devoted to keeping their reef built up to the level of the sea. Some doubt has been thrown upon the universally satisfactory character of this explanation, which we owe to Charles Darwin; but it is practically certain that, in some cases, at least, the existence of coral reefs rising as sheer pinnacles out of the deep water of the Pacific can only be explained by the gradual subsidence of the sea bottom.

Living Proofs of Land Movements. Other proofs of the gradual subsidence of the land are derived from the distribution of living plants and animals. Thus, it is fairly obvious that our own island must at one time have been joined by a strip of land to the continent of Europe, because no particular difference is found in either flora or fauna as we cross the Channel, which, indeed, is only of geologically modern origin. Its existence is solely due to the sinking of the land and the consequent invasion of the sea. Again, the Norwegian fjords and many of the Scottish and Irish Sea lochs present all the characteristics of river valleys, or glens, which the sea only entered long after they had been carved out by the running streams. In other words, the coast-lines on which such fjords and lochs occur have subsided since their formation. In many cases, also, the history of mankind, brief and almost evanescent though it is in comparison with the awful length of the great geological record, affords proof of the subsidence of coast-lines. On the coast of Sweden, Dalmatia, and Japan—indeed, on almost all civilised shores—ancient buildings are now found below high-water mark.

Unconformities. In not a few instances the study of the layers, or beds, in which the stratified rocks are arranged shows that elevation or subsidence of the land has taken place. We find, for example, that ancient beds, laid down by deposit from the sea in roughly horizontal planes, have thereafter been folded, or contorted, by movements of the crust [37], which will be explained later. In later ages, these folds, or contortions, have again been worn down by the erosion due to terrestrial agencies, until a comparatively flat surface has been left, and upon this flat surface fresh marine deposits have again been laid in horizontal planes, beneath which the older strata are found lying at many different angles.

Where this phenomenon occurs it is known as an *unconformity*, and its existence invariably shows that the land has once formed part of an ancient sea-bottom, has then been raised above the sea-level, and subjected to atmospherical and similar agencies of denudation, and has then once more been submerged beneath the sea and covered by the deposit of fresh layers.

38. DISTANT AND CLOSE VIEWS OF THE PARALLEL ROADS, GLEN ROY, SCOTLAND

Cause of Secular Earth Movements. Having convinced ourselves that the land does actually rise and fall through long ages, it remains to inquire why this should be the case. A little thought will enable us to reach a plausible answer, which has the further merit of being exactly true. If the earth were a solid body throughout, and uniform in temperature, there would be no reason why any part of its surface should change its position with regard to the rest. The agencies of denudation would be allowed to work their way with unchecked dominion, and the whole earth would ultimately be reduced to one dead level, which the waters of the ocean would cover to a depth which was practically the same throughout. But, fortunately for us, the earth is still alive. The fiery legacy of the nebula from which it was cooled is still potent to preserve it from this threatening fate. The earth is still cooling, and, in accordance with the law which affects practically all cooling bodies, as it loses heat it shrinks, or contracts. But the rate of this contraction is not uniform. The outer layers of the crust remain, and have long remained, at a constant temperature; consequently, it is the inner portion, or heated nucleus, of the earth which continues to shrink, while the solid crust remains firm.

The Earth in Wrinkles. The result of this process is exactly the same as that which produces wrinkles on the skin of a withered apple or on the human face. The central substance, as it shrinks, leaves the rind, or skin, or crust behind, and the latter, which sooner or later lacks the strength to hold its early form, is obliged to adapt itself to circumstances. This it does in the case of the human face or the apple by wrinkling into folds; and exactly the same thing takes place in the crust of the earth. The mountain chains and valleys, which form a prominent feature of the earth's surface, were all caused in the first instance by the gradual folding of the earth's crust as it settled down upon the shrinking core. This process is still going forward, though, of course, at a much slower pace, and with much less marked effects than in the early days of the earth when the Alps and Andes and Himalayas were formed. It is this process of crumpling, or folding, in the earth's crust which is able to

account for the greater part of the upheavals and subsidences which the surface of the earth is known to have undergone. It might seem that the contraction of the earth is only competent to account for subsidence, but a moment's thought will show that such a process of wrinkling, or distortion, as we have described will give rise to subsidence in one place and to upheaval in another [37].

Further, other and secondary causes, closely allied to the secular cooling of the earth, have been invoked to account for the local rising or falling of the land. If, for instance, a portion of the underlying crust be exceptionally heated by the intrusion of molten rock from below, as no doubt happens at the birth of a new volcano, it is reasonable to suppose that the explosion due to this heating may elevate a considerable track of land on the surface. Conversely, the contraction of a subterranean lake of molten lava, as it cools and hardens, may cause the ground immediately above it to subside—much as on a smaller scale we know that the ground often subsides over the workings of mines, or the hollow strata from which salt has been pumped out in the form of brine. We are still very far from forming a clear and perfectly scientific idea of what actually goes on in the lower regions of the earth's crust. But there can be very little doubt that the secular movements of the earth's crust, whether of elevation or of subsidence, are intimately connected with the cooling and consequent shrinkage of the earth's heated interior.

Chemical Action Underground. The last form of hypogene action which we have to consider is that which brings about actual changes in the character or composition of the rocks in the great subterranean laboratory where they were originally formed. The effects thus produced are mainly due to one or more of three causes—heat, pressure, and solution. As a rule, more than one of these causes operates at the same time. A rock may be influenced by heat and pressure and the action of water all at the same time, or by any two of them. Thus, it may be pointed out that marble, which is a crystalline limestone, is due to the heating of the ordinary calcareous rocks under pressure. If limestone be fiercely heated on the surface of the earth, we know that we shall succeed only in driving off its carbonic acid gas, and leaving quicklime; but experiment has shown that if it be heated under great pressure, the limestone, instead of losing its carbonic acid gas, actually melts, and if it be allowed to cool slowly it crystallises into marble. Under the pressure of strata many thousands of feet in thickness it is easy to see that the high temperatures existing at such depths as these may have turned limestone into the existing deposits of marble. Again, the heat of the lower regions of the crust, or of vast intrusive masses of lava welling up toward the surface, may exercise a baking and hardening effect upon the sedimentary rock with which they come in contact.

39. BANDED SLATE SHEARED VERTICALLY, HEMMICK COVE, CORNWALL

Subterranean Water. The solvent power of water upon rocks is accordingly increased when the water is heated or contains various chemical agents, as is undoubtedly the case in the lower regions of the earth's crust. Thus, in certain cases great changes are produced in the structures of rocks by the removal of some of their original constituents, through solution in water, which carries them away, or by the deposit of other substances which the water had dissolved and brought from another part of the crust, or by an actual chemical change in the minerals composing these rocks.

The remarkable snake-like rock known as serpentine has thus been produced from the original olivine. Limestone, which is very

soluble in water, especially in the presence of carbonic acid gas, is often found to have been replaced entirely by another mineral, such as silica, which betrays its origin by assuming the typical crystalline form of the original rock, like what in popular language is called a petrification.

Effects of Underground Pressure. The effect of the pressure of overlying strata upon rocks at great depths beneath the crust may be very considerable. It may roughly be considered that the pressure thus exerted upon a rock is about one ton to the square inch for every 1500 feet of superincumbent strata. It is difficult to realise what far-reaching and tremendous effects such a pressure as exists at a depth of 100 miles must have upon the rocks. The strata at these depths are ruptured and dislocated, or consolidated into extraordinarily compact masses.

in quite a different direction from them, showing that they have been produced by pressure acting at the ends of the planes of stratification and at right angles to them.

The phenomena of cleavage are largely due to a molecular rearrangement of the minute particles of the rock, which all tend to turn their longer axis perpendicular to the direction of pressure, much as may be observed with dates or raisins which have been pressed into a solid lump. The fossils which are sometimes found in rocks which have undergone cleavage confirm this view by showing that they have been greatly distorted from their original shape.

The Making of Coal. One of the most important processes carried out in the great subterranean laboratory, from a human point of view, is the conversion of vegetable substance into coal. This takes place, as a rule, when the

40. WHERE THE SEA ONCE FLOWED—A VIEW FROM REIGATE HILL

The effect of pressure which we have specially to notice here is to produce the phenomena known as *cleavage*. It has been found by experiment that such a substance as beeswax, when subjected to a severe pressure, develops "cleavage planes," along which it can readily be split into a series of thin plates. Many rocks are found to have developed similar cleavage planes under the severe pressure which they have undergone at a depth of some miles beneath the surface of the earth. Slates, which owe their commercial value to the readiness with which they can be split into thin plates along their cleavage planes, afford an excellent instance [39]. Originally they consisted of hardened clay, which no doubt presented the ordinary strata, or bedding planes, that characterise all sedimentary rocks. The cleavage planes which have been induced by pressure have superseded these planes in the altered strata, and, as a rule, run

vegetable substance is exposed to the action of water at a temperature and under a pressure considerably greater than those which obtain at the surface. Under these conditions, the gases are gradually driven off from the vegetable matter, and the proportion of carbon thus increases until, after passing through the various stages of peat, lignite, and bituminous coal, it ultimately reaches the condition of anthracite, or even of graphite, which is almost pure carbon.

It should here be added that subterranean water frequently contains minerals which serve as a cement for the loose grains of sand or gravel through which it percolates. Carbonate of lime, silica, and some iron oxides are the principal components of these cements, to which a large number of rocks of sedimentary origin now owe their consistency. Conglomerate, or puddingstone, breccia, and various sandstones, afford instances of this. W. E. GARRETT FISHER

The Scope of Engineering. Its Theory and Practice.
The Several Departments. Castings and their Patterns.

ENGINEERS' WORKSHOP PRACTICE

There are few, if any, of the professions or manufactures which are so many-sided or so exacting in their technical demands as mechanical engineering. The practice of it involves so much of science and theory, handicraft and machine operation, of general knowledge so wide, and specialisation so minute, that a successful engineer must never cease to be a student and a worker too. The early years of training are in but a slight degree preparatory to the work that comes after, the bare foundation on which the superstructure of life's long practice is reared.

Many Trades in One. A most interesting feature about an engineering works is that, though it comprises an assemblage of various kinds of shops, it forms an organic whole. From one point of view each department seems to stand alone, yet each is actually dependent upon all the rest, and the work of the management consists largely in keeping things moving between departments in order to secure the economical production of the final mechanisms. The foundry must not be short of patterns, nor the turnery and the machine-shop be kept idly waiting for castings and forgings. Every element in a machine, whether it be a massive casting or forging, or a little bolt, has to pass through more than one set of hands in its progress to the mechanism in which it finds a home. If error is made in one shop it entails inevitable trouble in another, and therefore engineering practice differs in these respects from some other trades where a piece of work is begun and finished in one shop only. This practice in a typical works involves the following departments of activity.

Design and Drawing. In a well-conducted works, no piece of mechanism is made until its design and dimensions, with all particulars as to materials and methods of construction, have been definitely settled and embodied in suitable drawings for use in the shops. The men who do this work must combine a knowledge of theory with that of practice, for if they are deficient in the latter their design will prove either unworkable or unnecessarily expensive, an evil which does arise not infrequently.

The Pattern Shop. The pattern shop and foundry are two distinct departments, in which the methods and materials have not the least resemblance to each other; yet they are the two most intimately related shops of any in the works. The first-named would be taken by a casual visitor for a carpenter's shop; the engineers' carpenters and pattern-makers, in fact, often work together. But beyond the feature which both trades have in common, of working in wood, there is no resemblance. The fact that the pattern has to be used in the formation of a mould for casting into renders its construction essentially different from that of a mere piece of woodwork. A carpenter could not make a pattern, simply because he does not know the methods of moulding—knowledge which the pattern-maker has to possess in addition to the technique of the carpenter.

The Foundry. The work done in the foundry is the making of moulds, and casting, or founding, of metal into the impressions produced by the patterns. But the *foundry* is an extremely comprehensive term, including numerous divisions carried on by different men in different buildings. Iron, brass, and steel castings are always kept entirely separate; so, generally, is aluminium. And within each of these are many subdivisions under the charge of specialists, as green sand moulding, work in loam, core making; or, again, hand work and machine work; while others, yet more minute, in which one class and size of casting only is done, year in, year out, as engine cylinders, pumps, railway chairs, brake blocks, and so on.

The Smithy. In the smithy, forged work alone is produced, but here also by different methods, as at the anvil alone by hand, or under power hammers, operated either by steam, belting, water, or compressed air. These correspond with two great subdivisions, that of the anvil smith and the stamper; the first named a craftsman, the second very often a comparatively unskilled man, who nevertheless may turn out twenty, forty, fifty times more products than the skilled smith working by handicraft alone.

The Boiler Shop. The boiler-making shop and the plating departments are two great and important shops, which, though generally kept distinct, have much in common, since they both use plates of steel and iron, and rolled sections of the same materials, in the form of angles, channels, tees, etc.; and they both adopt similar methods of union—that of rivets and of welds. In some respects, too, their methods resemble those of the smithy, but the crafts are always kept distinct, and carried on by different sets of men.

Erecting and Assembling Shops. In the erecting and assembling shops the prepared units are built up into the complete machine. The difference between them is that in the erecting shops much hand work is done, and none in the other. This, as we shall see, is a very important distinction in the economy of production.

These do not exhaust the departments which are found in large representative engineering works. Coppersmiths' and tinmen's work are

present in many—as in locomotive and marine shops, in pump makers' and brewers' engineering establishments. Heavy carpentry is done in crane shops, in locomotive shops, and in those who do work for civil engineers. Many engineering firms now make their own electrical apparatus for motor driving and for lighting, and there is then a wiring department. Painting and polishing shops, too, are often a part of the equipment of a big factory.

An important section is the testing department, which may include testing of raw materials as well as of finished products. Every motor, machine, and the mechanisms made to specifications must be subjected to tests of some kind, and the nature of these, of course, varies much with the character of the work—that for a steam boiler, for example, being of a very different kind from that of a machine or a bridge.

CASTINGS & THEIR PATTERNS

It is intended in this section to consider the work of the pattern-maker and moulder together instead of approaching them as isolated trades. The pattern is regarded from the point of view of its mould, as the means by which the casting is obtained, for the pattern is temporary, the casting permanent ; only in this way can correct views be gathered.

If we except the very small proportion of moulds made in plaster, and in metal (in iron moulds), all founders' work is prepared in sand—loose, powdery, friable—the poorest material, apparently, to withstand the inrush of molten metal, the high specific gravity of which is only disguised by its molten, fluid condition, for liquid iron is seven times heavier than water. And yet this sand will endure either the invasion of tons upon tons of molten iron or steel, or the few pounds of brass melted in a crucible. It is in the preparation, manipulation, and support afforded to the sand that the secret lies.

Moulding Material. Little difficulty need be experienced in understanding why the founder must employ this material in preparing his moulds. Think of almost any substance but sand, and the necessary conditions will be absent. The material must be obviously non-inflammable, which condition excludes wood or wax. It must be capable of being moulded into a thousand diverse forms, which excludes rigid metals—except for chill moulding, to be noticed presently. It must be very porous, to permit of the escape of gases generated during casting. It must cohere firmly, and not be acted on chemically by molten metal in such a way that the essential properties just noted should be changed. Lastly, it must be very abundant in nature, and cheap. Sand is the only substance which fulfils the whole of these conditions, which explains why all moulding and casting, with some very slight exceptions, is done in this substance.

The Moulding Box. But, though there is considerable coherence in sand when moistened with water, that alone is not sufficient to sustain the materials in moulds without extraneous aids. Hence we have the moulding-boxes, or flasks, within which the sand is rammed, and retained during making and casting. The differences in these boxes will be illustrated in another part of this course. Nor is the support of the boxes alone sufficient in all cases, since in most moulds there are many very weak sections or tongues of sand that are neither self-sustaining nor strong enough to withstand the rush and pressure of metal. Such weak portions have to be stiffened by the adventitious aids of "lifters" or "gaggers," rods, and nails—the internal skeletons, as the moulding-boxes fulfil the function of external skeletons.

When we go a stage further, and attempt to construct actual moulds, the discovery is soon made that all sands are not alike, and that there are certain properties that must be possessed by different sands, and mixtures of the same, for different classes of work, which are designated by various terms that denote their characteristics. Highly siliceous, heat-resisting sands occur in many districts, and to these are added coal-dust, or, in some cases, horse manure, in the following manner.

Moulders designate sand as *strong* or *weak*—terms which distinguish respectively the material of greater from that of lesser resistance. Within these extremes there are numerous grades of each. Horse manure enters into the composition of all strong sands, ill-digested hay affording a good binding material, which also, when burnt out by the heat of the molten metal, assists in the *venting* of the sand. Strong, close, heavy, clayey sand has the disadvantage of being less porous than the weaker sands, and therefore it requires more venting, both with the vent wire and horse manure, than the other.

At these extremes the components of sand mixtures are composed of clayey sands, and of fine, sharp sands. The first are often of a yellow colour, the second red.

A Practical Test. A practical test of the difference in quality is to squeeze a handful. If it retains the shape imparted, it is suitable for general moulding ; if too heavy, and decidedly clayey, it should have a finer sand mixed with it ; if it falls to pieces on the removal of the fingers, it is too *open*, and needs to have a stiffer clayey sand mixed with it.

Actually, in foundries only a small proportion of new sand is used in moulds, the old or "black sand" on the floor forming the largest body of the mould, or *box filling*, and the new sand being mixed for *facing* the moulds only, to a thickness varying from an inch to two or three inches. The stronger the sand is required, the less old sand can be used for intermixing.

Strong clayey sand requires another ingredient—coal dust—in large proportions, to counteract its closeness of texture and render it better able to permit of the discharge of the gases generated by casting. This has the effect of rendering the mould more open, because, being burnt out at the time of casting, it leaves the sand to that extent porous.

The stronger sands are used in those classes of work where the mould is subject to great

pressure of metal, and to prolonged heat; the weaker for the light casts, where there is little pressure and little mass, so that the process of cooling takes place quickly.

Kinds of Sand. The difference between *green sand* and *dried sand* corresponds to a certain extent with the *weak* and *strong* sands respectively. But many green-sand moulds are made in strong sand, though no dried moulds can be made with weak sand. "Green sand" denotes any mixture, weak or strong, that is *not dried*; "dried sand" is a particular mixture of strong sand, containing old and new sand, horse manure, ground loam, and moistened with clay water.

Cores are the internal parts of moulds. They are made of various kinds of sands, similarly to moulds, ranging thus from fine red or yellow sands to mixtures of dried sands, loam, and horse manure, with other sands. But *core sand* denotes a strong sand, which has to be dried.

Whether sands are weak or strong, green or dried, it is essential that they shall be able to resist the pressure of metal without distortion or fracture, and that they shall offer no obstacle to the escape of the gas generated by casting. We now propose to discuss the method of ramming and supporting the sand.

But first a reference is necessary to the other materials of moulds just mentioned. These, a very small class, may be briefly disposed of.

Plaster of Paris is used for a few small moulds in the jewellery trades, and occasionally for small brass work. Its advantage is that several casts can be made from one matrix. But it is limited to such cases, and has no place in the general engineer's foundry.

Chill or chilled moulds are used in cases where special hardness is required on the surface only of a casting, all the casting body remaining soft. Its utilities are confined to a few articles, such as some trolley wheels, chilled on the "tread," or periphery; rolls for working on iron and steel plates; ploughshares hardened at the points and on one face; some machine slides, and the bores of some axle boxes. The *chilling* is accomplished by pouring the metal against a cold iron "chill," which produces a steely face. Excepting on the face thus chilled, all the remainder is ordinary metal cast in sand.

Ramming. We come to the methods of *ramming*. In all moulds, except some which are very shallow, ramming is essential to the proper consolidation of the sand around the patterns. These exceptions occur chiefly in such work as making foundry lifters or gaggers, some rough and shallow kinds of fire-bars, etc. But in all ordinary work, whether deep or shallow, the sand must be rammed round the pattern.

Another fact is that no mould can be produced which will fulfil the conditions just named unless the whole of the sand is thus rammed in detail. It is not sufficient to throw in the whole boxful of sand, trample it down, flat-ram, and strickle it off. Bit by bit every inch of the sand must be consolidated with the rammers, and the nearer to the pattern it lies, and the more slender its projecting portions, the greater must be the care exercised in ramming it. All ramming must begin in corners, around flanges, bosses, prints, before the main body of the sand is filled in. The flat rammer is not used in doing this work, but the "pegging" rammers, two forms of which are shown in **1** and **2**, or else —as is often the case in very small moulds— a bit of round rod ⅜in. or ½in. diameter, is employed to press home the sand. Only as much sand is thrown in as can be rammed properly. It may be a handful only, or a few shovelfuls, depending on the mould.

The Force of Ramming. Little by little the sand which lies immediately next the pattern is rammed thus in detail, using facing sand first, taking care not to bruise the pattern by allowing the rammer to come in contact with it. As the work proceeds, the facing is backed up by the old sand from the floor for box filling. This is also rammed in detail, but so much care is not necessary here as in working the facing sand. It has simply to afford backing, or support, to the sand that is next the pattern. In very small moulds no such distinction need be made, but one kind of sand would be used throughout.

When the box part is filled up to the height of, say, an inch above the joint face, the flat rammer [**3**] is employed to finish the whole to an equal consistence on the top, and the strickle and trowel level the joint face.

The force which is put into ramming varies. Taking extremes, light, soft ramming results in castings covered with lumps, the imperfectly rammed sand yielding locally to the pressure of the metal. On the other hand, heavy, hard ramming is productive of "scabbing," the sand flaking off owing to the bubbling of the metal against a surface too hard to permit of the complete escape of gases. But these results can be and are modified by the nature of the sand mixtures used, by the extent of the venting done, and by the location of the rammed part. Thus, a well-dried mould will endure without risk hard ramming that could not be put into a damp mould. And the more moisture there is in a mould, the more risk there is of swelling, or scabbing, occurring through light or hard ramming respectively. This is the reason why many green sand masses are "skin-dried" only on the outside. Again, much harder ramming can be done if the vent wire is freely used than if it is sparingly employed.

The location of the rammed part is of great importance in determining the degree of hardness or softness of the ramming. The bottom and the top of a mould are those which are subject to greater pressure and most liable to scab. These should be rammed harder than the sides, and vented most. Frequently, in fact, a stronger sand is used for the top than for the sides. Sometimes the top is dried, while the sides are green. Sometimes loam cake is rammed in those portions of the bottom of a deep mould against which the metal beats or falls during the pouring.

Venting. The term *venting* signifies piercing the sand, during intervals of ramming, with innumerable fine holes, produced by a vent wire [**4**],

ranging from one-sixteenth to a quarter of an inch in diameter. Through these vent-holes the gases escape at the time of casting and immediately following thereon. The vents, therefore, act as safety valves to moulds which would otherwise become blown up, broken, and damaged, which happens in some degree when the venting is insufficient. *A*, in **4**, is a strip of wood held down on the mould joint to prevent the sand from becoming pulled up on the withdrawal of the vent wire, *B*.

Many sections of the sand require support, as previously mentioned, other than that due to the consistency of the moistened and rammed material. Nails, rods, and lifters are the means employed. It is not enough to lay these in the mould; they must have something to take hold of or be supported on—as lifters hung from the bars of boxes, and rods and nails which overhang, receiving their support in the main body of the sand. Such adjuncts are carried in any direction where they are wanted in moulds, and, being dipped in clay water, the sand sticks around them, and is held in place. These will be illustrated in another section, dealing with the divisions of the moulder's work.

Difficulties. Having thus dealt with the general methods of ramming, we must now regard the subject from another point of view. Various castings and patterns are shown in the illustrations which are given in this section, with the methods of dealing with them in order to obtain moulds of the same shapes. Obviously, though it is easy to enclose the patterns in sand, properly rammed, it is necessary to know how to get them out again without damage to the mould. This is a wide problem, often puzzling even to men in the trade when intricate work is involved. Of course, the examples given here are not difficult; they are selected as representative of leading principles.

The difficulties of the engineer's pupil or apprentice in deciding upon the form of mould required for the infinite varieties of castings are of a different character from those which exist in the actual work of the machine shop, or smithy, or boiler shop. They involve the production of forms which exist first only on drawings, more or less intricate, and which have to be made by methods that often permit of several alternatives, all practical, perhaps, but not all economical, or mechanically desirable.

Often the pupil or apprentice will see that very slight and apparently unimportant variations in form involve a different method of making; that different men will arrive at the same result by the adoption of dissimilar methods; and sometimes it happens that, after a pattern has been made to mould in one particular way, the moulder will get it altered to mould in another.

All these are puzzles to the beginner, and they serve to encircle the foundry craft with an air of mystery. It is not so difficult when a man has grasped the principles thoroughly, and had some experience, to settle a suitable method of making any mould whatever, even though he has never seen anything precisely like it before.

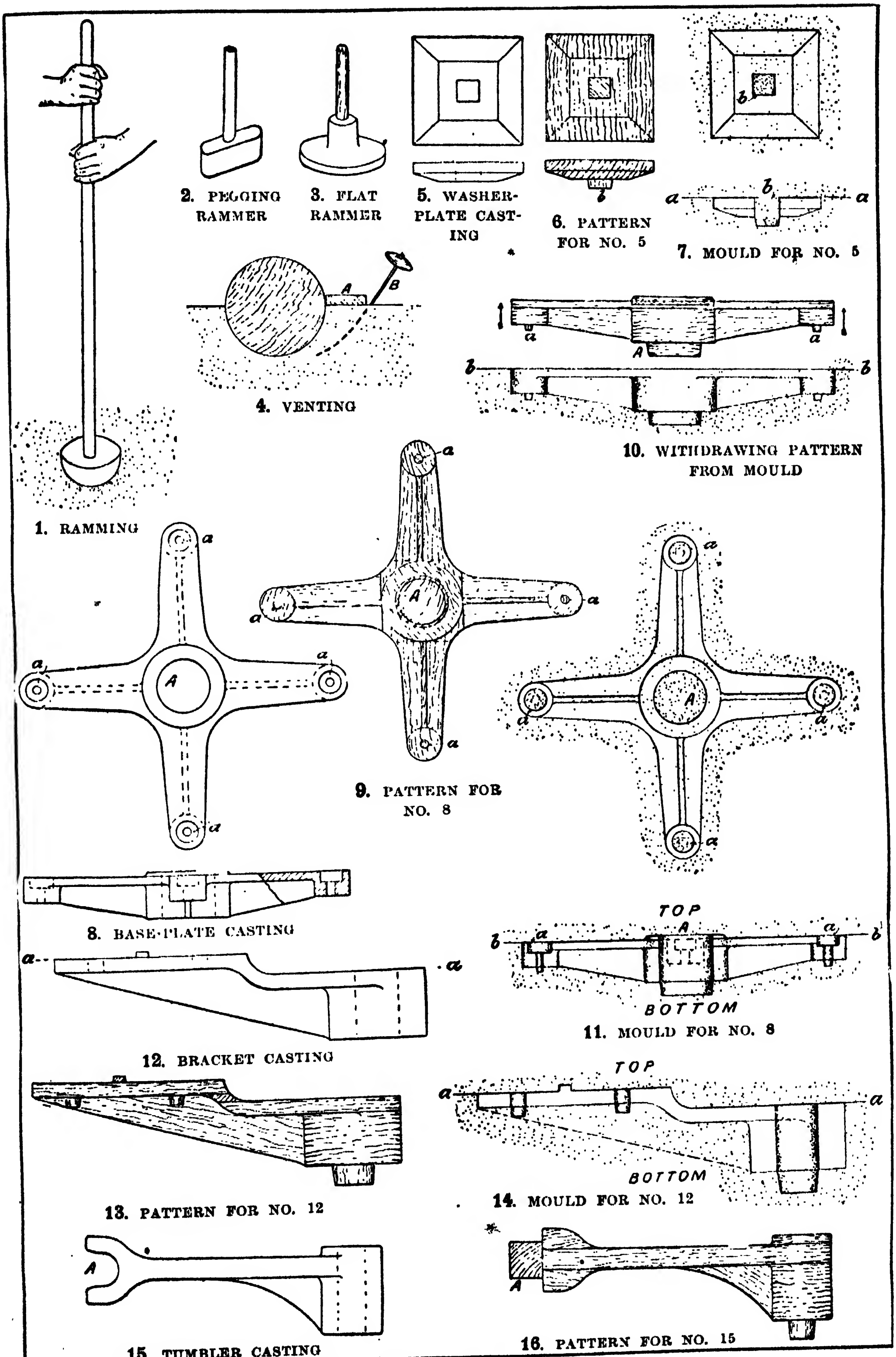
Fig. **5** is the simplest thing possible, a plain washer plate. Its pattern is seen in **6**. This is moulded with the flat face uppermost, in a plane with the joint *a-a* of the top and bottom boxes [**7**]. The reason is that, if moulded with the bevelled edges uppermost, the moulder's sand joint would occupy more time in making. The hole is formed with a separate dried core, *b* inserted in the impression made by the print *b* in **6**, because it is easier to core cleanly than to allow the sand to deliver from a hole in the pattern. But if so delivered, which is often done, about one-eighth of an inch of "taper" would have to be imparted to the sides, and then the hole could not be cast parallel. The upper part of **7** shows how the opened mould appears in plan, with the core inserted, ready to be covered with the top box of the mould.

Crane Base. Fig. **8** gives views of a baseplate for a wharf crane. In plan it has the shape of a cross. It is moulded with the vertical ribbing downwards, because less damage is inflicted on a mould by withdrawing the pattern out of the sand than there would be if, the ribs being uppermost, the sand were pulled up away from them. This is a very important practical detail, and it explains why, when deep ribs must for various reasons come sometimes in the top, they are left loosely attached to the pattern. Then they remain embedded in the sand of the top box, while the latter is being lifted, and when it has been turned over the ribs are pulled out just as they would be from the bottom portion of a mould.

The holes *A*, for the central post, and for the foundation bolts, *a a a a* [**8**], are cored, for self-delivery would be impracticable. Fig. **9** shows the pattern in plan, looking on the ribbed face, with the core prints lettered similarly to the holes in **8**. Fig. **10** is a cross section through the pattern just delivered from its mould below, and **11**, upper figure, is the open mould—*i.e.*, not covered with its top box, the jointing of which is in the plane *b-b*, **11**, lower figure; and both showing the cores in place, lettered similarly to the holes and core prints in the figures preceding.

The bracket casting shown in side view [**12**] is moulded with the rib lowermost for the reason just given, and the sand joint *a-a* between top and bottom box follows the top face of the pattern. The holes for the shaft and those for the bolts are cored. There are two alternatives. In one the bracket would mould as it lies in the drawing, the rib lying horizontally; in the other, the rib would come in the top box. Either would give rather more trouble than the method we illustrate. Fig. **13** shows the pattern construction, with its prints; **14**, a section through the cored-up mould.

Prints and Cores. The tumbler bracket [**15**] must mould with its two arms [compare with **17**] in the same horizontal plane, and properly with the deeper boss lowermost as shown, for the reasons just now mentioned in speaking of ribs. There is then no chance for the shaft-bearings, *A*, to deliver, and therefore they are cored out. The prints and cores are indicated in the pattern and mould [**16** and **17**] respectively. A point to note

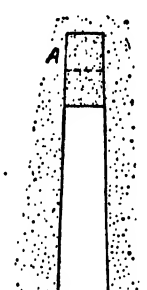


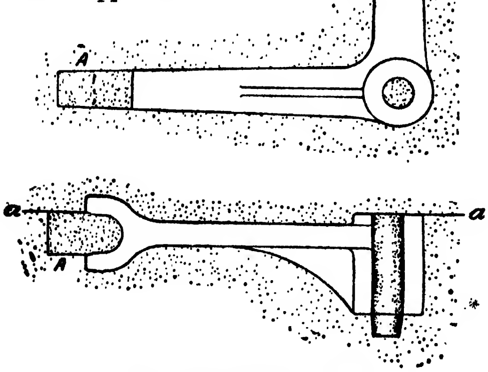
1-16. ILLUSTRATIONS OF PATTERNS AND MOULDS

is that the print *A* is made sufficiently wide to afford support to the core, without the supplementary aids of chaplet nails. The joint between the top and bottom boxes runs along the edges *a-a*, which extend from the top of the print around the upper edges of the pattern absolutely.

The pawl [**18**], in which a similar shaft hole, *A*, occurs, is not cored, because it will deliver its own sand. And it is a matter of indifference whether it moulds with the joint at *a-a* [**18**] or quarter round in the plane of the paper. The irregular jointing between top and bottom necessary in each case is about equal in amount. The only difference made is that in one case the core for the fulcrum hole, *b*, is put in a round print impression, and in the other in the impression of "pocket" or "drop prints," to which we shall come presently. Generally, this slight difference would result in a decision in favour of the former method, because the simpler of the two. Fig. **19** shows the mould made by the former method, with top and bottom separated ready for closing. It illustrates how the sand must follow those outlines of the pattern which will afford free delivery.

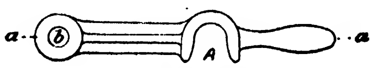
Points at Issue. There are some fundamental points which may be disposed of briefly here. First, with regard to the method of producing these moulds. The details of making them are not illustrated yet, but only the *relations* of the moulds to their patterns, and without reference to their frames or moulding-boxes. In speaking of ramming, we remarked the necessity of operating in detail. Now, you cannot do that properly underneath a pattern, with a flat area, as, say, **6**, **9**, or **13**. Such patterns are therefore moulded by *turning over*, which is the first broad division in the moulder's work. That is, the face which is finally lowermost in the mould is at first uppermost, and is



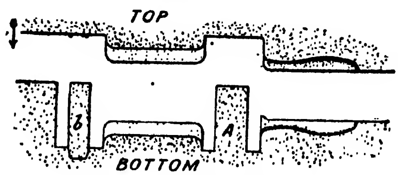


17. MOULD FOR NO. 15

rammed thus directly, and afterwards turned over, when the actual upper face is rammed. And this helps to explain why the position of a casting in the mechanism of which it forms a part does not concern the moulder in the least. He simply regards it from the point of view of how best to ram and pour it. But when, as often happens, moulds of large dimensions have to be made without turning over,



18. PAWL CASTING



19. MOULD FOR NO. 18

then the ramming is a tedious process, because the pattern has to be taken out from time to time to permit of getting at the sand beneath properly. Fig. **4** is an example of a pattern that would be more easily rammed underneath than **9** or **13**.

Joints and the Moulding. Further, we see that while the joints between the top and the bottom of the mould are sometimes plane, as in **7** and **11**, in others they have to follow non-plane outlines, as in **14**, **17**, and **19**. It does not follow that the joints of the moulding-boxes must be non-plane. They are only so in a few very special cases. The irregular sand joints are sleeked within boxes that have flat joints.

As the joints of the top and bottom moulds have to be separated before patterns can be withdrawn, a separation must be made in the sand of the top and bottom. This is done by strewing a thin layer of another kind of sand between, termed *parting sand*. This is sand which has been burnt, being red sand baked in the core stove, or the scrapings from castings. In each case no moisture is present, and so the sand does not stick to the rest with which it comes into contact, but parts the two mould sections.

The Use of Simple Core Prints. Looking at the functions of the very simple core prints shown, the question arises: why would not holes cut in the patterns deliver from the sand as well as the exterior edges, say, of their bosses? It is a natural question, and the reason is apparent only on experience of the work of moulding. Take, say, the large boss core in **17**, and suppose a hole to be cut in the boss to deliver its own core. During the loosening of the pattern by "rapping," preparatory to delivery, that small cylinder of sand would become cracked, and on the lifting of the pattern would be torn to pieces. The sand without the boss does not tear up, because the rapping squeezes it back slightly into the good sand backing around it. It is therefore necessary to make an impression (print) for small holes, and insert hard, dried cores subsequently.

JOSEPH G. HORNER

Spanish: Reflective Verbs. German: Interrogative Pronouns, the Prepositions and Verb. French: the Indefinite Pronouns.

SPANISH

Continued from page 2365

By José Plá Cárceles, B.A.

Reflective Verbs. A verb is called reflective when its object is a person or thing identical with the subject —*yo me lavo,* I wash myself.

The reflective personal pronouns "myself," "thyself," "himself," "herself," and "yourself" are rendered by *me, te, se;* and "ourselves," "yourselves, "yourselves" (fam. form.), and "themselves" are respectively translated by *nos, se, os,* and *se.*

The position of these reflective forms with regard to their verb is the same as that of the conjunctive personal pronouns. [See page 1972.]

Not all verbs which are reflective in Spanish must be assumed to be so in English. The infinitive of a reflective verb may be easily recognised, because it is invariably composed of the usual form of the infinitive and the termination *se* (oneself).—*esconderse,* to hide oneself. The final *s* or *d* of the first and second persons plural of the affirmative imperative is dropped in all reflective verbs.—*escondámonos,* let us hide ourselves: *escondeos,* hide yourselves.

Conjugation of Reflective Verbs. *Levantarse,* "to get up," may be taken as a model for reflective verbs, which, it must be noted, are exceedingly common in Spanish.

PRESENT INDICATIVE OF *Levantarse*

Singular	*Plural*
me levanto, I get up	*nos levantamos,* we get up
te levantas	*os levantais*
se levanta	*se levantan*

IMPERFECT

no me levantaba, I used not to get up
no se levantaba, he used not to get up
no nos levantábamos, we used not to get up

PAST DEFINITE

se levantó, he got up — *nos levantamos,* we got up
se levantaron, they got up

FUTURE

no me levantaré, I shall not get up
no te levantarás, thou shalt not get up
no os levantareis, you will not get up

CONDITIONAL

se levantaría, he should get up
nos levantaríamos, we should get up
se levantarían, they should get up

IMPERATIVE

levántate, get up
levántese Vd, get up
levantémonos, let us get up
no se levanten Vds, do not get up

EXERCISE XXXIII

to be like	*parecerse á*	to sit down	*sentarse*
to be glad	*alegrarse*	to alight	*bajarse*
to go to bed	*acostarse*	to wake up	*despertarse*
to get angry	*enfadarse*	to swim	*nadar*
to get tired	*cansarse*	to laugh	*reirse*
to retire	*retirarse*	to refuse	
to bathe	*bañarse*	to lodge	*alojarse*
to move	*mudarse*	to walk	*andar*
to know how	*saber*	the demand	*la demanda*
to hope	*esperar*	increase	*aumento*
until	*hasta*	the seaside	*la playa*
during	*durante*	the village	*la aldea*

to make up one's mind	*decidirse*
to take advantage	*aprovecharse*
to establish oneself	*establecerse*
to make a mistake	*equivocarse*
to raise the price	*subir el precio*
to enjoy oneself	*divertirse*
to trouble oneself	*molestarse*
to get married to	*casarse con*
to catch a cold	*resfriarse*
to praise oneself	*alabarse*
to say good-bye	*despedirse*
to wash oneself	*lavarse*
the daughter	*la hija*
the royal palace	*el palacio real*
the central market	*el mercado central*

1. He was glad to (trans. *de*) see me. 2. I hope (that) you will enjoy yourselves. 3. They went to bed so late because they had to wait for their father. 4. We did not sit down during the whole evening. 5. It would be so easy to make a mistake. 6. Do not trouble yourself. 7. The cashier gets very (trans. *mucho*) angry when we make a mistake. 8. Alight in front of the Royal Palace. 9. They will soon get tired if they walk so quickly. 10. We used not to wake up until half-past seven. 11. Do you think he will retire from (the) business next year? 12. I think he will retire if his daughter gets married to his partner. 13. Make up your mind. 14. I caught a cold at the seaside. 15. Did you bathe? 16. No; I do not know how (*no sé*) to swim. 17. We should establish ourselves near the central market. 18. They took advantage of the great increase in the demand to raise their (trans. *los*) prices. 19. She used to praise herself too much. 20. I had to say good-bye to (trans. *de*) all my friends. 21. They would laugh. 22. We refuse to accept their terms. 23. Where can I (*puedo*) wash myself? 24. He is like a friend of mine. 25. The soldiers were lodged in the houses of the village. 26. We moved to this house a few (*algunos*) days afterwards.

When a reflective verb used in the plural refers to two or more persons separately it is called *reciprocal,* and the reflective pronoun *se* must be translated into English by "each other" if only two persons are meant, and by "one another" when the subjects of the verb are several.—*se comprenden,* they understand each other; *se ayudan,* they help one another.

As sometimes the meaning of the sentence may be doubtful, it is usual in such cases to

make it clearer by some addition.—*se conocen á sí mismos,* they know themselves; *se conocen el uno al otro,* or *mútuamente,* they know each other; *se conocen los unos á los otros,* they know one another.

Verbs expressing a state of transition are very frequently reflective in Spanish. Thus, to become, *convertirse;* to fall asleep, *dormirse.* Sometimes the reflective form is used to denote a modification of the idea expressed by the original verb.—*abonar,* to pay; *abonarse,* to subscribe.

Impersonal Sentences. Many impersonal sentences which in English are constructed in the passive voice, or with the aid of words like "people," "they," used in a general sense, must be rendered into Spanish by the reflective form of the verb.—*se decía,* it was said, people said; *se dan lecciones,* lessons given.

EXERCISE XXXIV

to comment	*comentar*	to omit	*suprimir*
to admit	*admitir*	to serve	*servir*
to request	*suplicar*	to apply	*solicitar*
to prohibit	*prohibir*	to issue	*despachar*
to let	*alquilar*	to make	*hacer*
to do	*hacer*	to repair	*componer*
to take time	*tardar tiempo*	by land	*por tierra*
to continue	*continuar*	by sea	*por mar*
page	*página*	silence	*silencio*
yearly	*al año*	dog	*perro*
rent	*alquiler*	the result	*el resultado*
ballot	*votación*	to measure	*á medida*
site	*solar*	vowel	*vocal*
suit	*traje*	to want	*necesitar*

nowadays	*en la actualidad*
public works	*obras públicas*
second hand	*de segunda mano*
everywhere	*en todas partes*
on horseback	*á caballo*
how long?	*¿cuanto tiempo?*
furnished flat	*piso amueblado*
shorthand writer	*taquígrafo*
to collect (cash)	*cobrar*

1. It is believed that they are more than ten. 2. People commented (on) the news. 3. Second-hand books bought, sold, and exchanged. 4. Is English spoken there? 5. I do not think so, but French is spoken everywhere. 6. No dogs admitted. 7. Silence requested. 8. People travel more nowadays. 9. The journey was then done on horseback. It took (imp.) twenty or thirty days 10 How long does it take (*se tarda*) from here to Barcelona? 11. It takes one day and a half by land and seven or (*ú*) eight days by sea. 12. Money lent. 13. The result of the ballot is not yet known. 14. Sold everywhere. 15. Two millions are yearly spent in public works. 16. It will be continued next week. 17. Spanish shorthand writer wanted. 18. Smoking (trans. *fumar*) prohibited. 19. Is foreign money exchanged in the hotel? 20. I think so. 21. Furnished flat to let (*se alquila*). 22. How is this word pronounced? 23. The last vowel is omitted. 24. That site is sold at (a) low price. 25. At what time will dinner be served? 26. At seven o'clock sharp. 27. Tickets issued here. 28. Rents collected. 29. Suits made to measure. 30. Trunks repaired. 31. See (*véase la*) page one hundred and six. 32. Apply (*solicítese*) by letter. 33. Ask for (*pídase la*) price list.

KEY TO EXERCISE XXXI

1. ¿ Lo vendería Vd. á ese precio? 2. No, sería un fracaso. 3. ¿ Qué me aconsejaría Vd.? 4. Yo se lo explicaría otra vez. 5. Los consignatarios no pagarían el exceso de ningún modo. 6. ¿ Cree Vd. que sería más barato enviar los géneros por barcos de vela? 7. Tendríamos que nombrar agentes en varios puertos. 8. ¿ No sería mejor esperar? 9. Eso implicaría mayores gastos.

KEY TO EXERCISE XXXII

1. ¿ Cuantas circulares impresas envió Vd. por correo? 2. No he enviado ninguna hoy. 3. ¿ Ha estado alguien aquí esta mañana? 4. No, señor; no ha venido nadie. 5. Gastaba demasiado dinero. 6. Ese banco tiene demasiadas sucursales en Colombia. 7. Haga el favor de darme más leche. 8. ¿ Desea Vd. algo? 9. No; no deseo nada. 10. ¿ Venden periódicos alemanes? 11. Creo que sí. 12. ¿ Dónde compró Vd. esos pañuelos? 13. Compré todas las cosas en la misma tienda. 14. Cada casa tiene un jardín pequeño á la espalda. 15. Todos los trenes paran en la frontera. 16. Me ha dado algo. 17. Encontramos á algunos amigos en el teatro. 18. El otro sillón es más cómodo. 19. Recibimos muy pocos pedidos de Escocia. 20. Ambos son de la misma opinión.

Continued

GERMAN

Continued from page 2369

By P. G. Konody and Dr. Osten

Interrogative Pronouns

XXXIX. The INTERROGATIVE PRONOUNS are: (*a*) wer? who? (*b*) was? what? (*c*) welcher (*m.*), welche (*f.*), welches (*n.*)? which? and (*d*) was für ein (*m.* and *n.*), eine (*f.*)? what sort of? Wer and was are used substantively; the former applied to persons, the latter to objects. The declension of (*a*), (*b*), (*c*) is set out in the table on the next page.

Examples: (*a*) Wer fragt? Who is asking? (*b*) Was sagst du? What do you say?

1. Welcher, welche, welches is always either directly connected with, or used with reference to, a substantive; it has the character of an attributive adjective and is declined like one [see XXVI.] When used as an exclamation, it takes the shortened and indeclinable form welch, similar to the demonstrative pronoun solcher, solch, and mancher (many a), manch ein. In this case it is either followed by the substantive with or without an adjective, or by the indefinite article—for instance: welch schöner Tag, what [a] beautiful day; welch schöne Landschaft, what [a] beautiful landscape; or, with inserted indefinite article: welch ein schöner Tag, welch eine schöne Landschaft.

2. The indefinite article can *never* precede the interrogative pronoun welcher, whilst it may precede the demonstrative solcher: ein solcher Tag! such a day, but welch' ein Tag! what a day.

	(a)	(b)	(c)	Plural for all 3 genders
nom.	wer	was	welcher welche welches	welche
gen.	wessen (wes *)	wessen (wes)	welches (en) welcher welches (en)	welcher
dat.	wem	—	welchem welcher welchem	welchen
acc.	wen	was	welchen welche welches	welche

* Used in proverbs, etc.: Wes das Herz voll ist, geht der Mund über, Of what the heart is full, the mouth overflows.

3. Was für? What sort of? which? cannot be declined, and is used in direct connection with substantives denoting materials and abstract ideas—for instance: Was für Wein? What sort of wine? was für Glaube? which creed? In all other cases the indefinite article is inserted: was für ein Hut ist das? what sort of hat is that? The indefinite article is of course declinable. Without substantive was für ein? takes the lengthened form was für einer (*m.*)? was für eine (*f.*)? was für eines (*n.*)? and is used substantively. Ein having no plural, the plural of was für ein is expressed by was für welche?

4. If the interrogative pronoun was? (what?) is used with the prepositions an, auf, über, nach, zu, etc. [see XXV.], it is replaced by the adverb w o, contracted with the prepositions (woran? worauf? worüber? wonach? wozu? etc.), the latter being placed at the end. For the sake of euphony an r is inserted between two vowels. It is not usual to say: An was denken Sie? What are you thinking of? but: W o r a n denken Sie? nor: Zu was dient dieses Rad? What purpose does this wheel serve? but: W o z u dient dieses Rad?

Prepositions

XL. The following is a complete list of the German prepositions arranged according to the cases ruled by them:

Prepositions Governing the Genitive

anstatt' (or statt), instead of
au'ßerhalb, outside of, (without)
dies'seits, this side of
halber (or halben *), on behalf of
jen'seits, that side of
in'nerhalb, within
kraft, by power of
längs †, along
laut, according to
um . . . willen, for the sake of
un'beschadet, without prejudice to
un'geachtet, despite, although
un'terhalb, beneath, below
un'weit (or unfern †), not far from
vermö'ge, in virtue of, by means of
vermit'telst (or mittels), by means of
o'berhalb, above
trotz ‡, in spite of
wäh'rend, whilst, during
wegen *, on account of
zufolge †, according to, in consequence of

* Is *always preceded* by the substantive: des lieben Friedens halber, for the sake of [dear] peace.
† Also used with the dative.

Prepositions Governing the Dative

aus, out of, from
außer, except
bei, near, about, with
binnen, within
entgegen, against
gegenü'ber, opposite
gemäß', according to
mit, with
nach, after
nächst (zunächst'), next to
nebst, with, together with
ob §, on account of
sammt, together, with
seit, since
von, from, of, by
zu, to
zuwi'der, contrary to

Prepositions Governing the Accusative

bis, till
durch, through
entlang ¶, along
für, for
gegen, against, towards
oh'ne, without
um, for, about, around, on account of
wider, against, contrary to

* Can be alternately preceded or followed by the substantive: Wegen des lieben Friedens, or des lieben Friedens wegen, for the sake of [dear] peace.

† Also used with the dative, if *preceded* by the substantive—for instance: Einem Berichte zufolge (*dat.*), according to a report; but: Zufolge eines Berichtes (*gen.*).

‡ Also used with the dative.

§ In poetic speech also with the genitive: Ob dieser Kunde (*gen.*) herrschte Trauer rings im Land, On account of this news mourning reigned throughout the land.

¶ Sometimes used with the dative, and very rarely with the genitive.

For the prepositions governing alternately the dative and the accusative, and for the contractions of prepositions with the definite article, see XXV.

Classification of Verbs

XLI. The classification of verbs is most important, as it is the basis for the rules concerning the employment of the auxiliary verbs s e i n and h a b e n.

As regards their dependence and influence on other nouns, the verbs can be classified as follows: (*a*) *intransitive*, (*b*) *transitive*, (*c*) *reflective* and *reciprocal* [see 5], and (*d*) *impersonal* verbs [see 6].

(*a*) Intransitive verbs want no completion to convey their full meaning—for instance: die Sonne scheint, the sun shines; der Wind bläst, the wind blows, etc.

(*b*) Transitive verbs require the aid of objects in the accusative to make their meaning fully obvious—for instance: das Kind liebt seine Eltern, the child loves its parents, etc. Transitive verbs can always be brought into the passive form if the *object* (accusative) is made the *subject* (nominative)—for instance: die Eltern werden von ihrem Kinde geliebt, the parents are loved by their child.

1. There are some verbs which require completion by a noun in the genitive or dative—*e.g.*: bedür'fen, to require, want; raten, to advise, etc.; ich bedarf deiner, I want [of] thee; and rate mir, advise me. These are not counted among the

transitive verbs, the characteristic of which is the power to govern a noun in the accusative, but among the intransitive verbs.

2. Other verbs are used with prepositions and are thus connected with complementary nouns in the cases required by the prepositions—*e.g.:* wir lachten über ihn (*acc.*), we laughed at him; er strebte nach Reichtum (*dat.*), he strove for wealth, etc. Bear in mind the essential difference between the *prepositional-accusative* of the intransitive and the *object-accusative* of the transitive verbs.

3. The same difference occurs in the case of the accusative determining the *measure* and answering to the questions: how much? how far? how long? etc., which always determine the *intransitive* character of the verb—for instance: der Kauf'mann wog den Zucker, the merchant (grocer) weighed the sugar (transitive); but: der Zucker wog zehn Pfund, the sugar weighed ten pounds (intransitive with accusative of measure).

4. Intransitive verbs can also be brought into the passive form by the introduction of the impersonal es, it: die Sonne scheint, the sun is shining; and: es wird von der Sonne geschienen, which, though correct, is a clumsy form and should not be used.

5. Some verbs are only used in connection with certain personal pronouns, in the sense that the action is reflected upon the acting person. The complement (object) is here identical with the subject—for instance: Ich sehne mich nach etwas, I long for something; er schämt sich, he is ashamed, etc. These are called *reflective verbs.* If the acting persons are in the plural, a reciprocity of reflection may take place, in which case the verbs are called *reciprocal*: sie ärgerten einander, they annoyed one another (each other).

6. *Impersonal* verbs denote either natural phenomena ascribed to impersonal agency, and are therefore used with the impersonal es, it; (examples: es regnet, it is raining; es donnert, it is thundering, etc.); or the impersonal action of certain feelings or sensations on persons: es hungert mich, I am hungry [it hungers me], etc. Verbs are also used impersonally to denote occurrences due to some impersonal motive power; es giebt ein Wie'dersehen, in the sense of there is the possibility of seeing each other again.

7. Many verbs belong alternately to both groups—the transitive and the intransitive—according to their relation to the object of the sentence.

Exercise 1 [see last lesson]. Change the present tense in the following sentences into the imperfect and pluperfect. (Mind the arrangement of the sentence with regard to the past participle and finite verb.)

Ich nehme das Geld; der Knabe stiehlt einen Apfel; I take the money; the boy steals an apple; was geschieht? ich lese ein Buch; ihr seht what happens? I am reading a book; you see nichts; geben Sie nichts? du verbirgst nothing; do you give nothing? thou hidest etwas; wir werfen den Ball; die Dame spricht something; we throw the ball; the lady speaks englisch; ich esse Erd'beeren; English; I eat strawberries; er vergißt alles. he forgets everything.

Exercise 2. Insert the correct plural terminations of the following words with double plural form:

Das Lustspiel hat vier Akt . . .; in seinen Träumen The comedy has four acts; in his dreams hatte er seltsame Gesicht . . .; die Ritter erhoben ihre he had queer visions; the knights raised their Schilde . . .; der Richter brachte die Akt . . . . Alle shields; the judge brought the documents; all hatten bleiche Gesicht . . .; die Schild . . . über den Laden- had pale faces; the sign-boards above the shop-türen waren gemalt; wie viele . . . . haben Sie? doors were painted; how many volumes have you? Die . . . . . . des Hutes sind rot; die . . . . der Vögel The ribbons of the hat are red; the birdcages waren aus Gold; die . . . . kennen das Wetter. were of gold; the peasants know the weather.

Exercise 3. Insert in the blank spaces the missing interrogative pronouns:

. . . . . ist dieser Herr? . . . . meinen Sie? Who is this gentleman? What do you mean? . . . . . . Hut ist das? . . . . . . gehört dieses Buch? Whose hat is this? To whom belongs this book? . . . . sahen Sie gestern? . . . . Manne Whom did you see yesterday? To which man gehört das Boot? . . . . . Dame kennen Sie? belongs the boat? Which lady do you know? . . . . Kinder sollen eingeladen werden? . . . . . glänzender Which children are to be invited? What [a] brilliant Spieler er ist! . . . . . . schöne Kind sahen Sie? player he is! Which beautiful child did you see? . . . . schönes Kind! . . . . Leute What [a] beautiful child! What sort of people sind sie? . . . . Getränke bestellten Sie? are they? What drinks did you order? . . . . Frau war es? What sort of woman was it?

Exercise 4. Insert the missing words and terminations in the cases required by the prepositions:

Diesseits . . . Mauer (*f.*), innerhalb . . . Garten . . (*m.*), On this side of the wall, within the garden, stand ein Mann inmitten . . . . Wiese (*f.*). stood a man in the midst of the meadow. Zufolge ein . . Bericht . . (*m.*) war der Feind geflohen, and: Ein . . Bericht . . zufolge war der Feind geflohen. According to a report, the enemy had fled. Trotz mein . . Warnung . . (*f.*) sprach er mit ihm; In spite of my warnings, he spoke with him; um . . . Himmel . . (*m.*) willen! Mein . . Hauf . . gegenüber for heaven's sake! Opposite to my house wohnt ein Schneider seit ein . . Jahr . . (*m.*); ich öffnete lives a tailor since a year; (a tailor has been living for a year) I opened mittelst . . . . Schlüssel . . (*m.*) die Türe. Seit the door with (by means of) a key. Since Ihr . . Abreise (*f.*) sah ich ihn nicht mehr. your departure I did not see him any more.

KEYS TO EXERCISES [PAGE 2369]

EXERCISE 1. *Imperfect:* Ich band einen Kranz; der Vogel sang; das Reh sprang und trank; das Werk gelang; wir tranken Wein; das Wasser rann ins Thal; er schwamm ausgezeichnet; ich saß im Garten; das Schiff sank; die Glocke klang laut; der arme Mann bat, etc.; ich gewann das Spiel.

Perfect: Ich habe einen Kranz gebunden; der Vogel hat gesungen; das Reh ist gesprungen und hat getrunken; das Werk ist gelungen; wir haben Wein getrunken; das Wasser ist ins Tal geronnen; er ist ausgezeichnet geschwommen; ich bin im Garten gesessen; das Schiff ist gesunken; die Glocke hat laut geklungen; der arme Mann hat um eine Unterstützung gebeten; ich habe das Spiel gewonnen.

EXERCISE 2. Ein solcher Freund ist selten; solch ein Freund ist selten; er ist der Sohn dieses Mannes und jener Frau; wir sprachen mit diesem Knaben und mit jenen Männern; sie sprach viel von ihrer Tochter und von deren Erfahrungen; der Himmel ist jenen gnädig, die ihn anrufen; der Jäger marschierte hinter seinem Herrn und trug dessen Gewehr.

EXERCISE 3. (*a*) Es ist eine Freude, einen solchen Sohn zu haben. Ein solches Unglück! Eines solchen Mannes Sohn sollte von anderer Art sein. Wie konnten Sie einer solchen Frau eine solche Unhöflichkeit sagen? Ein solcher Tag ist schrecklich. Einem solchen Künstler muß man einen solchen Irrtum verzeihen.

(*b*) Solch ein Skandal wegen solch einer Kleinigkeit! Solch eines Mannes Pflicht ist Großmut; solch einem Unglück gegenüber ist der Mensch wehrlos; solch einen Fall habe ich in solch einer Familie noch nicht erlebt!

Continued

FRENCH

Continued from page 2367

By Louis A. Barbé, B.A.

INDEFINITE PRONOUNS

The indefinite pronouns (*pronoms indéfinis*) are: *On, quiconque, quelqu'un, quelque chose, personne, rien, chacun, autrui, l'un l'autre, l'un et l'autre.*

1. *On*, one, they, people. *On* is very widely used in French. It is always the subject of a verb in the third person singular. It may be translated literally by "one," and occasionally by "some one":

(*a*) *On doit obéir aux lois,*
One must obey the laws.

(*b*) *On nous a indiqué le chemin,*
Someone showed us the road.

When (as in *a*) *on* has a collective meaning, and includes the speaker, it may be rendered by "we": "We must obey the laws." When it is collective, but does not include the speaker, *on* may be translated by "people," or by "they":

On craint ce roi et on lui obéit, mais on ne l'aime pas, People fear that king and obey him, but they do not love him.

Very often an English passive construction supplies the best rendering of a French sentence that has *on* for its subject: "That king is feared and obeyed, but he is not loved."

When *on* is preceded by *si*, if; *ou*, or; *où*, where; *que*, whom, that; *qui*, who, and *et* in which the final *t* is silent, it usually takes *l'* before it, to avoid the hiatus caused by two vowel sounds:

On n'aime pas à voir ceux à qui l'on doit tant,
We do not like to see those to whom we owe so much.

This *l'* must not be used when the word coming after *on* begins with *l'*:

On l'admire et on l'aime, He is admired and loved.

On must be repeated before every verb of which it is the subject:

On le loue, on le menace, on le caresse,
They praise, threaten, caress him.

2. *Quiconque*, whoever, is always followed by a singular verb:

Quiconque est riche, est tout,
Whoever is rich, is everything.

Words in agreement with either *on* or *quiconque* may be feminine if the sense absolutely requires it:

Quand on est mère on ne doit pas être coquette,
When one is a mother, one should not be a coquette;

Quiconque est vraiment mère n'est plus coquette,
Whoever is a real mother is no longer a coquette.

3. *Quelqu'un* has two different meanings, according as it is used absolutely—that is, without reference to a noun, or relatively, that is, with reference to a noun.

When *quelqu'un* is used absolutely it means "someone," "anyone," and applies to persons only:

Quelqu'un a dit que le soleil est l'âme du monde,
Someone has said that the sun is the soul of the world.

Quelqu'un doute-t-il sérieusement de l'existence de Dieu? Does anyone seriously doubt the existence of God?

When *quelqu'un* is used relatively, it applies to both persons and things, and means "some," "any," "a few." It is then used chiefly in the plural, and has either *de* and a noun after it, or *en* before the verb if the noun is understood:

Connaissez-vous quelques-unes de ces dames? Do you know any of those ladies?

J'en connais quelques-unes, I know a few of them.

Avez-vous encore de ces livres? Have you any more of those books?

J'en ai encore quelques-uns, I still have a few.

Quelqu'un, quelqu'une, quelques-uns, quelques-unes, require *de* before an adjective qualifying them:

Je connais quelqu'un de plus riche que lui,
I know someone richer than he.

4. *Quelque chose*, as an indefinite pronominal expression, requires words in agreement with it to be masculine, and adjectives qualifying it to be accompanied by *de*. It has the meaning of "something," "anything":

Il y a dans ce livre quelque chose d'incomplet.
There is something incomplete in that book.

Autre chose, something else, anything else, and *grand'chose*, much, are used in the same way, and follow the same rule as *quelque chose :*

Avez-vous autre chose de curieux à nous montrer?
Have you anything else curious to show us ?
Il n'a pas fait grand'chose de bon,
He has not done much that was any good.

5. *Personne*, when joined to *ne*, is negative, and means no one. It is used without *ne*, and with the meaning of "anyone" in interrogative sentences, or in sentences expressing doubt. Words in agreement with it are masculine, and adjectives qualifying it are preceded by *de :*

Il n'y a personne d'assez hardi,
There is nobody bold enough.
Y a-t-il personne d'assez hardi ?
Is there any one bold enough ?

6. *Rien* is negative, and means "nothing," when it is accompanied by *ne*. It may be used without *ne*, and with the meaning of "anything" in interrogative sentences, or in sentences expressing doubt. Adjectives qualifying it take *de :*

Il n'y a rien de nouveau, There is nothing new.
Y a-t-il rien de plus désagréable ?
Is there anything more disagreeable ?

7. *Chacun*, like *quelqu'un*, may be used either absolutely or relatively. In the former case, it applies to persons only, and has no feminine form. It means "each one" :

Chacun croit avoir assez de sens commun, Each one thinks he has enough common-sense. When used relatively, it applies to both persons and things, and has a feminine form, *chacune :*

Ces gravures me coûtent cinquante francs chacune,
Those engravings cost me fifty francs each.
Chacun de ses enfants a remporté un prix,
Each of his children has carried off a prize.

8. *Autrui*, though rendered by the English, "others," is always singular. It may not be used as a subject, and only occurs in connection with *à* or *de :*

Attendez d'autrui ce que vous faites à autrui,
Expect from others what you do unto others.

9. *L'un l'autre*, one another, each other, has the feminine form *l'une l'autre*, and the plural forms *les uns les autres, les unes les autres*. In a sentence, the first part of this expression is always the subject, and the second part the object of the verb. Consequently, only the second part can have a preposition before it :

Ils médisent l'un de l'autre,
They speak evil of one another.
Les vrais chrétiens se pardonnent les uns aux autres,
True Christians forgive each other.

10. *L'un et l'autre* and its feminine form *l'une et l'autre* mean "both." When used with a personal pronoun, they cannot come immediately after it :

Ils rapportent l'un et l'autre les mêmes circonstances,
They both relate the same circumstances.

The plural forms *les uns et les autres, les unes et les autres* have no nearer English equivalent than "all" :

Ils se réunissent les uns et les autres contre l'ennemi commun, They all unite against the common enemy.

Exercise XVIII

1. Where can (*peut*) one be better than in the bosom (*au sein*) of one's (*sa*) family (*famille*) ?
2. We have been told to (*de*) give you this.
3. They obey (to) that king because (*parce que*) they fear him, but nobody loves him.
4. He is said to be very rich.
5. Whoever has done that is a bad man.
6. If anyone speaks to you answer (*répondez*) him (to him).
7. I know no one here, and no one knows me.
8. If you have any more (*encore*) of those pears, give me a few.
9. Someone asks to (*à*) speak to you.
10. We have learnt (*appris*) something very interesting.
11. I know someone more powerful (*puissant*) than he.
12. We have not done much good to-day.
13. There is nothing more pleasant than travelling on foot (*de voyager à pied*).
14. Is there anything more surprising than this story ?
15. Each of my friends has carried off two or three prizes.
16. Do (*faites*) unto others what you would like (*voudriez*) that others should do (*fît*) to you.
17. I have spoken to both.
18. True Christians do not speak ill of one another.

Key to Exercise XVII.

1. Cette plume (-ci) est bonne, mais celle-là est meilleure.
2. Elle m'a montré son chapeau et celui de sa sœur.
3. J'aime mieux les nôtres que les leurs.
4. Si ce n'est pas lui c'est son frère.
5. Qui sont ces demoiselles ? Ce sont nos cousines.
6. Ce monsieur est-il avocat ? Non ; il est médecin.
7. C'est un de nos médecins les plus distingués.
8. Je ne connais pas ce monsieur ; je l'ai vu une ou deux fois, c'est vrai, mais je ne lui ai jamais parlé.
9. Il est vrai que nous ne lui avons jamais parlé, mais nous le connaissons très bien de vue.
10. Avez-vous fait cela ? Non ; ce n'est pas moi, c'est lui.
11. Si vous avez de plus belles gravures montrez-les-moi, je n'aime pas celles-ci.
12. Ce que vous venez de lire est très intéressant, mais ce n'est pas vrai.
13. Cette chambre-ci est plus petite que la nôtre, c'est la plus petite de toute la maison.
14. Donnez-moi un autre mouchoir, s'il vous plaît, j'ai perdu le mien.
15. Nos fleurs sont belles, celles de votre sœur sont encore plus belles, mais les vôtres sont les plus belles.
16. Cette bague n'est pas à moi, je n'en ai pas, elle est à une de mes amies.
17. Ce n'est pas sa bague, à elle, qu'elle a perdue, c'est la mienne.
18. À qui est-ce de jouer ? C'est à vous.

Continued

Effective Bows and Rosettes of All Kinds. The Butterfly and Alsatian Bow. Chiffon and Tulle Rosettes. Lace Quills and Fans.

MILLINERY TRIMMINGS

MILLINERY bows are made in a great number of shapes and sizes. They may be made of silk ribbon of an immense variety of kinds and widths, velvet ribbon, lace, piece velvet, chiffon, tulle, straw, kid, braid, beaver, cloth, etc., but each bow is made on the same general principle. Before using new ribbon, it is better for an inexperienced worker to practise on a piece of muslin, or even tissue paper, cut in strips the width and length of the ribbon; for when once the ribbon is creased, it cannot very well be altered without taking away the freshness of its appearance. By practising in this way, the beginner will obtain that lightness of touch, quickness, and "finger-knack" which is so necessary in all millinery trimmings, and especially in bow-making. She will, in a short time, produce bows which would be a credit to an experienced milliner.

Bows are always made by hand before they are sewn on, except in the case of large hats with a bow or rosette at each side and a piece of ribbon going across the centre.

When making the bow, the hat for which the ribbon is needed should be in front of the worker, to get the size and effect. Bows are best made from one length of ribbon which is not more cut than necessary, unless a bow with many ends is required.

A bow, although it should appear to be untouched by hand, must yet be firm. When buying ribbons for bows take care that the assistant does not crease up the ribbon to show how it will look, as the crease may happen to come across the widest part of the loop. The following characteristics of a well-made bow should be noted:

Pleats should be even, fine, and straight;

Each loop and end brought back to its root or starting point, and the bow made in one piece, if possible;

The ribbon kept fresh-looking, free from twists and any re-arrangements;

The size of loops made in accordance with the width of the ribbon;

The wire (if used) firmly fixed, and the ribbon sewn lightly to it, free from strain.

We shall first make a few bows which never go out of fashion. To keep up-to-date in the latest shapes of bows it is necessary to study the fashions prevalent at the time. Those who have an opportunity of visiting trade houses will have a great advantage. Otherwise, careful observation of the best milliners' windows, of well-dressed people in the parks and promenades, of ladies' magazine advertisements, will help the milliner to see what is most in vogue. Even if she has no originality, she will at least be able to copy, after practising the instructions we shall give.

The quantity of material required for a simple bow is ¾ yd. of 5-in. wide ribbon. Start at one end—not in the middle. Hold the ribbon in the right hand, and with the left pleat it firmly and evenly.

Bind it *tightly* round the pleats with mounting wire, inserting one end of the wire in the pleat; or with cotton, using a strong needle and No. 10 cotton. Insert the needle once through the pleats and turn the cotton round tightly three times; put the needle through again [128].

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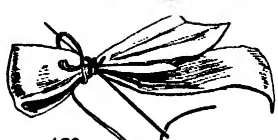
Gauge the length of the loop by the width of the ribbon—the wider the ribbon the longer the loops. Pleat the ribbon *evenly*, and bring the pleated part back to the centre, and bind it tightly with mounting wire or cotton, having the loop *opposite* the end just made [129]. This centre is called the *root* or *waist* of the bow.

If there is a right and wrong side to the ribbon, as there is in velvet ribbon with satin back and most ribbons with patterns on them, give it a sharp twist to keep the right side up, before making the second loop. To pull up the loop, place the forefinger inside. Never crease or touch bows more than is just necessary to secure them.



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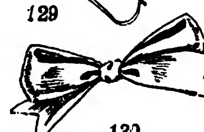

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128–130. A SIMPLE BOW

Make another loop in the opposite direction, which will place it on the top of the first end, and for this simple bow make it the same length as the first loop, bringing it back to the root or starting point. Cut off the ends slantways, or fray them out. The triangular piece cut from the first end will make the tie-over. Turn in cut edges, twist it over the root, and neatly finish off at the back with a few stitches [130].

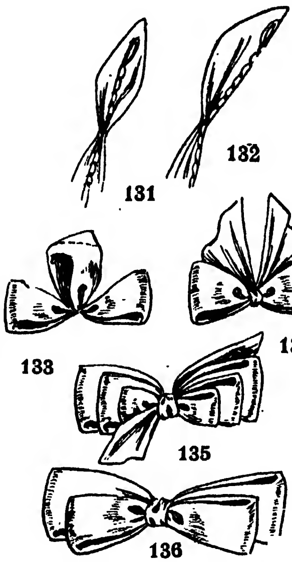
On this principle all other bows are made. They may be varied by having several loops of different lengths, but they are always placed alternately right and left to the root.

Good ribbons require no stiffening, provided the loops are not too long. Large bows of wide ribbon, and all soft ribbons, require wiring. Use support wire or ribbon wire, shredded. Of the last, use each strand of the wire separately, which can easily be done by tearing it along the soft part. Wire-stitch it along the centre, and zig-zag it for wider soft ribbons. Use very fine sewing silk to match the ribbon, and let the stitch taken

through be hardly visible [131 and 132]. In the same way, coloured support wire to match the ribbon can be used. It is a little more difficult to manipulate, but a lighter effect is obtained.

Ribbon wire can also be used. Place the end of the ribbon wire inside the centre pleat, bring the needle through, bind it round with cotton, and take the needle through again. Gauge the length for the loop, and allow the same length for the ribbon wire; bind it over with the ribbon, and stitch it and bind round the root of the bow. Be careful not to strain the ribbon tightly on the wire.

Secure the wire at the back with silk to match the ribbon, just below the top of the loop.



THREE STYLES OF BOWS
131 and 132. Wiring the bow
133 and 134. Butterfly bow
135. A tied bow 136. Alsatian bow

Upstanding or broad ends should be wired half way up, never quite to the top. In some cases the ends are wired along one or both sides of the ribbon.

A butterfly bow [133 and 134] can be made in rather narrow width ribbon, in which case it will be used for bonnet trimming. It has two loops and two upstanding ends, shaped at the end as butterfly wings. It also makes a handsome trimming for front of hat if made of a ribbon 9 in. to 10 in. wide, or a piece of silk.

Start this time with a loop, pleating each side separately. Make another loop in the opposite direction; then another standing up in the centre, turning in the end inside, passing the cotton used to secure the bow at the root through and through the loop. Place the tie through the centre loop. Cut this slantways [134], and shape the ends like butterfly wings. Quantity of ribbon required is $\frac{5}{8}$ yd. of 2-in. wide ribbon velvet.

A tied bow [135] has as many loops of various sizes as desired, but only two ends, and is made, including the tie-over, in one piece. It is useful for children's washing hats and bonnets, and for various other millinery items. Keep the first and second loop the longest, graduating the length of each pair of loops. Begin with an end, next a loop 12 in. long, in opposite direction; another loop the same length, opposite the first, 12 in. long; then two loops 9 in. long, and two loops 6 in. long. Take the remainder of the ribbon, twist it round the root, and pull the end through the twist at the back; and the bow is finished. This bow can be made without the use of any cotton or mounting wire; the loops are kept firmly in place with the fingers till the tie-over—that is, the second end—secures them. Quantity of ribbon required is 1$\frac{3}{4}$ yd. 5 in. wide.

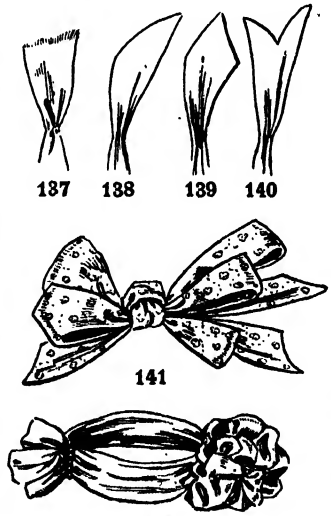
The Alsatian bow [136] takes 1$\frac{1}{4}$ yd. of 3-in. wide ribbon. It is made of four loops, has no ends, and a large broad tie-over. Loops Nos. 1 and 2 are 12 in. long; loops 3 and 4, 10 in. long. These are used frequently for nurses' bonnets, etc., the loops reaching from ear to ear from the centre of the bonnet, only once pleated in the centre.

Fancy bows [141 and 142], with more than two ends, and more than two or four loops, are made on the same principle as described, several of the loops being cut after the bow is made. If upstanding ends are required, the tie-over is taken round them, and for a flatter trimming the tie-over is taken in the centre in the usual way. Two and a half yards is the very least quantity which can be used to trim a hat satisfactorily; if it is to be its sole trimming, 3$\frac{1}{2}$ yd. is an average quantity. For ruches, loops, and rosettes, more is required.

Ends of bows may be frayed [137], cut in wing [138], mitred [139], or cut to fishtail shapes [140]. The ends are sometimes vandyked, or treated in some other fashionable way.

Kilting the ribbon [143] makes pretty, effective bows or rosettes. Plain ribbons look better kilted than brocade, chené, or fancy ribbons. Mixing ribbons of different tones of the same colour makes smart bows. In the good French ribbons at least three shades of the same colour can be obtained, toning gradually from light to darker.

Piece velvet bows [145] are made of velvet cut on the cross and the edges roll-hemmed. The loops are pleated as in ribbon bows; but as velvet is so much thicker, it should be twisted as little as possible, and if a large bow is required, it must be made in two parts. About $\frac{3}{4}$ yd. on the cross is required, and the tie-over should be neatly made.



A FANCY BOW AND ENDS
137-140. Bow ends
141 and 142. Fancy bows

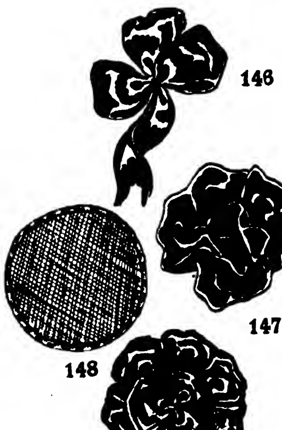
Bows of straw, braid, etc., are made in the same way. Lace insertion sewn between the rows of straw, or gauged tulle, chiffon, or silk all make pretty variations of bows. Two or even three colours of straw worked in one bow or rosette are also very effective [144].

In stitching bows to the hat, stitch firmly, stabbing the needle in the hat through the back part of the tie-over. Tie inside. Catch each loop to the brim with an invisible tie-stitch in a becoming position.

Rosettes. Rosettes are made in ribbon, lace, tulle, silk, velvet, or straw. Like bows they are continually changing in style, and even a greater variety and greater originality is displayed in the last new ones. The following are a few of the standard styles, which always remain in vogue.

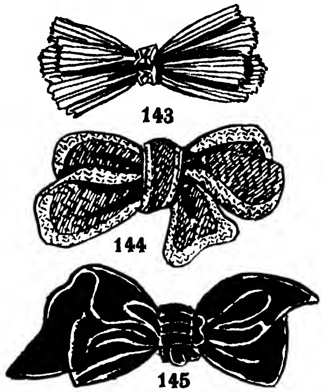
The loop rosette [**146**] consists of a succession of loops each made independently, but all coming back to the centre or starting point; $1\frac{3}{4}$ yd. of 7 in. wide ribbon is needed. Start with a loop 7 in. long. Pleat the ribbon and twist round the cotton at one end as in diagram **128**; take the ribbon over the forefinger and pleat at 7 in. Then bring it back to its starting point and twist round the cotton, which will form the centre or root. Make five, seven, or nine loops, each being brought back to the centre and the cotton twisted round. The number of loops depends on the width of ribbon and size of rosette desired.

Arrange the loops in circular order, finishing the last one in the centre, unless an ornament, floral, or other fancy centre is going to be made [**149**]. Be careful the loops are close together, for if each loop is not stitched to the starting point a gap will be left between, taking away the rounded, full look. The name "chou" is sometimes given to this rosette when made very full and with rounded top. Most of the other kinds of rosettes require a foundation to which to sew the loops. For this cut a circle, about 3 in. in diameter, of buckram or double French net [**148**]; wire round with support wire, overlapping the ends for 2 in., and bind with sarcenet ribbon. Another way of making a rosette is with very small loops only 3 in. in entire length, sewn on a foundation, round and round. It takes $4\frac{1}{2}$ yd. of ribbon for each rosette, and has a flat appearance.



ROSETTES
146 and 149. Loop rosette
147. Crossway rosette
148. Foundation for rosette

For crossway silk or velvet rosettes [**147**] cut the velvet or silk twice the width required, and let the length be according to the width and size of rosette. The narrower the velvet the smaller the rosette, and vice versâ. One crossway length of velvet of about $\frac{3}{4}$ yd. long and $3\frac{1}{2}$ in. wide makes a small rosette suitable for a bonnet, or to fill up a small space on a bandeau at the back of the hat. This size can be made without a foundation, and two lengths are better than one. To make this, shade and join the velvet; run the raw edges together with strong cotton and pull it up tightly. Sew it to a foundation; do not skimp the outside edge, and finish it off neatly in the centre.



FANCY BOWS
143. Kilted bow **144.** Straw bow
145. A piece velvet bow

Gathered ribbon rosettes are made in exactly the same way, except that the ribbon is, of course, on the straight. Gather it either along one edge or through the centre. Pull the cotton up tightly.

For silk rosettes, if not used double, roll hem-stitch, tuck, or bind one edge to form the trimming.

For crush rosettes of velvet or silk cut a circle of velvet or silk from 9 in. to 20 in. in diameter [**154**]. If the velvet or silk be soft, use a light leno or book-muslin for interlining. Gather it all round, draw up to the circumference of foundation. The centre will fall in light folds and puffs, which secure here and there to the foundation with the tie-stitch. The better the quality of the velvet, the lighter the rosette will look, and the fewer the stitches needed to keep the puffs in place [**150**].

Odd bits and cuttings of velvet or silk of any shape or size can be used for this rosette, gathered up round the edge and sewn in.

For baby ribbon rosettes [**151**] mark on a piece of net a circle the size of a shilling. Make each loop by folding the ribbon over the finger, and stitch it to a foundation on the outside of the circle marked, then another circle just inside, and so on until the foundation is covered. Finish in the centre with three upstanding loops. Quantity required is 6 yd.

There is another method of making these rosettes — without a foundation. Wind the ribbon entirely round a card $1\frac{1}{2}$ in. wide and about 7 in. in length. Let each loop just overlap the last, and do not wind tightly. With a needle and strong cotton run through the top of the loops, carefully picking up each one. Slip the ribbon from the card, removing the loops in succession, draw up tightly and fasten off securely.

Chiffon rosettes [**156**] need $1\frac{1}{2}$ yd. of double-width chiffon, cut through the centre selvedge way. This will make two or three smaller size rosettes.

Make a fold the width required; pin this down, and make another narrower fold, and pin again. Run two or three gathering threads through all the folds at the bottom, draw up tightly and stitch together; finish off the centre with an ornament. Pull out each fold to produce a full, rounded appearance.

Chiffon, net, or tulle rosettes are made with the material cut on the straight; run the two raw

edges together, draw up, and wind round from centre outwards.

For lisse, net, or tulle, the cut edges are sometimes turned to the centre, box-pleated there, and drawn up. The wider the rosette, the greater the amount of fulness required, as it will want more material to set without skimpiness round the outside edge. Avoid showing raw edges, and finish off the ends neatly.

Tulle rosettes take 2 yd. of double-width tulle and 6 yd. of lace insertion, ½ in. wide [155].

Cut the tulle in strips 9 in. wide, fold them in half, and sew the lace on to the fold so that it stands out well. Gather the two cut edges. The lace can be sewn on about ½ in. from the "centre edge." Tulle rosettes sometimes have their folded edges cut after they are drawn up; it gives a pretty, fluffy appearance, though they do not wear so well.

A cockade rosette [153] for bonnets or toques requires 1½ yd. of 8-in. wide ribbon; if two shades are used, ¾ yd. of each is enough.

Kilt the ribbon and make three ends; wire at one edge, unless a firm silk ribbon is used, and make two small loops and a tie-over.

For a drawn silk rosette [152] cut ¾ yd. of crossway silk in two lengths; join them in a circle. Run ½ in. tuck along the edge and another through the centre. Insert a cotton cord in each, and gather cut edges tightly to form the centre, which is finished with an ornament. Secure outer edge to foundation, also the second cord.

Kid, braid, or straw rosettes are made in the same way, but each of these requires a foundation.

Rosettes should be sewn to the hat, if possible, through the centre, or *between* the loops or flutes.

Hat Trimming. To sew on feathers, nip off any superfluous length of wire and bend up the remainder, which should be bound with a small piece of crossway velvet to prevent the cotton slipping off the stem or wire when sewing the feathers on.

When a quill end or fancy sheath is used, do not bind the end of the feather, but slip the stem in the sheaf, and sew through the quill end or the holes in it. Tie the cotton about 2 in. from the end of the feather on the under side; leave the cotton loose for about 1½ in., and tie in position to edge of brim, or wherever it is required to fall. A feather should never be fastened tight down to the brim. When it has to be stitched to a velvet hat, first sew it to a piece of stiff net, which can be secured to the hat more firmly and with fewer stitches. A buckle, ornament, or some other kind of trimming must neaten the end in this case.

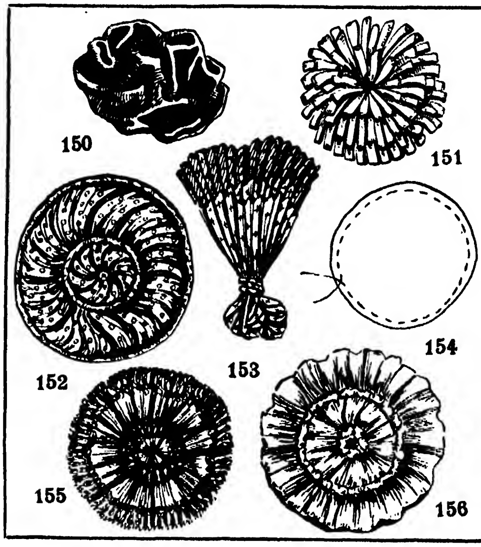
Feathers on lace or net hats are sewn to one or more wires; a piece of stiff net is placed at the back and the stitching taken through. Some feathers require to be wired down the stem, to make them retain their position. In this case use support wire, and nip round the end, making a small loop. The wire should leave off about 2 in. from the end.

Wings and quills are stitched securely at the base. Quills may even have a stitch taken through the stem, which can be done by using a No. 3 "between" needle. If wings are padded, secure them through that part. Sew the ends in position with the tie-stitch.

Jet and fancy ornaments, such as buckles, clasps, etc., must be always stitched in the centre as well as on each side, to prevent their slipping sideways.

To stitch on flowers or wreaths, cut off any unnecessary length of stem and bend up the remainder. Stitch the flowers firmly to the hat by taking the stitches over and over from side to side of the stem and cutting off those that are not needed. Arrange the flowers and foliage in position, and tie-stitch them to hat.

A trail of flowers is caught here and there with the tie-stitch very loosely to the shape. Coloured cotton to match must be used. No stitches should show, and the trimmings should look as if they are "laid" on the hat.



SOME EFFECTIVE ROSETTES

150 and 154. Velvet rosette 151. Baby ribbon rosette
152. Drawn silk rosette 153. Cockade rosette
155. Tulle rosette 156. Rosette of chiffon

Lace Quills. To make a lace quill or wing, place paper pattern on lace, net, or chiffon, and cut out with ¼ in. turnings. If the lace has a pattern, place that in the centre of the quill.

Wire-stitch with lace wire round the edge, turning the ¼ in. turning over the wire on the right side, and allow 2 in. to 3 in. of wire at each end, at the bottom, to form a stem.

A Lace Fan. The length required to make a lace fan depends on the fineness and depth of the lace. Lace 5 in. deep and 15 in. long will make a pretty little fan for a toque or bonnet.

Slope the 15 in. to 10 in. at the lower edge. Join it in a round. Nip round the wire ½ in. at the top to prevent the sharp edge tearing the lace. Wire-stitch the wire to the lace, the stitches just fitting round the wire; finish it off securely at the bottom, allowing 2 in. or 3 in. beyond the lace. Place one wire at the join, one in the centre, and one between the centre and ends.

Various Types of Pistols, Revolvers, Rifles, Sporting Guns, and Machine Guns. Their Mechanism and Manufacture.

THE MANUFACTURE OF GUNS

One of the most important and most skilled branches of metals manufacture is the making of guns, which we may take to include the wide range of weapons between the handy little revolver, small enough sometimes comfortably to fit the waistcoat pocket, and the monsters of many tons and comparatively short life, the ownership of which, according to their size and number, fixes the status of each nation as a power.

This and the following chapter briefly outline the development of gunmaking, and describe the mechanisms of the chief weapons in use on land, on the sea, and in the air.

Pistols. The present type of pistol has a steel rifle barrel [1] fixed or with a drop-down joint, with fixed breech parts containing the striker and mechanism. The barrel is forged steel and rifled, the lock plates are of iron and steel, stamped and milled, and the action part springs. The butt is of walnut. The barrels are blued or browned. But the pistol has been almost superseded by the revolver and automatic pistol. Many revolvers and guns were made during the last two centuries having the cylinder revolved by hand, but the metallic centre-fire cartridge has enabled a great advance to be made.

Modern Revolvers. The simplest modern type is the single-acting "Colt revolver" [2]. In this the cylinder, which contains six cartridge chambers, is made to rotate by the action of cocking the hammer. This causes pawls to engage in rachet teeth cut in the rear face of the cylinder, and move it one-sixth part of a revolution, and at the same time a small catch or latch engages in the recesses in the periphery of the cylinder, and locks it in position till the shot is fired and the lock is cocked again.

In a later type the cylinder was swung out sideways to give self-extraction [3]. This revolver had a solid bridge frame [FR in 2]. The frame or body is stamped hot—that is, forged by drop hammer between top and bottom dies. The fins of extended metal are dressed off by finning dies, and the stamping is then placed in a clamp jig or fixture for machining and the base pin hole is drilled through; the pin, previously prepared, is then inserted in order that each subsequent operation may conform with this centre. The frame still in the fixture is faced, the recess for the cylinder is machined out, and the barrel hole is drilled and tapped. The stock is shaped and spring beds recessed; all holes are then drilled and tapped, through the hardened bushes of the fixture. The frame is recessed for the hard steel shield which takes the thrust of the cartridge base.

The Cylinder. This is either forged or of special rolled steel. The centre axis pin-hole is first drilled through and the cylinder is faced. The chambers are drilled and bored six at one time, in a multiple drilling machine; afterwards they are accurately chambered out to suit the cartridge. The front face of the cylinder is well fitted to prevent, as far as possible, the escape of gas. In the periphery of the cylinder the channels are now cut; also the slots for the latches are accurately milled out to an index plate to ensure true pitch, in relation to each other and the corresponding chambers, and, at the rear end, the ratchet teeth are cut. The limbs, or parts of the action, are of high grade steel stamped hot approximately to their finished form, and also machined in jigs or fixtures by automatic tools.

The Barrel. The barrel is bored, rifled, and screwed; the outside is turned, the component parts are finished off by filing, and after hardening and tempering they are sent forward in the bulk for section viewing—that is, for detailed examination by gauges and to be assembled from promiscuous heaps, each part being thoroughly interchangeable. The sear and spring are then adjusted, to give a slight pull off, and the sighting corrected. Given these conditions, a champion revolver shot can fire as rapidly and accurately with a single-action revolver as with a double-action automatic [described later], the latter having a somewhat dragging pull. For competition purposes in this country the minimum "pull off" allowed is 4 lb.

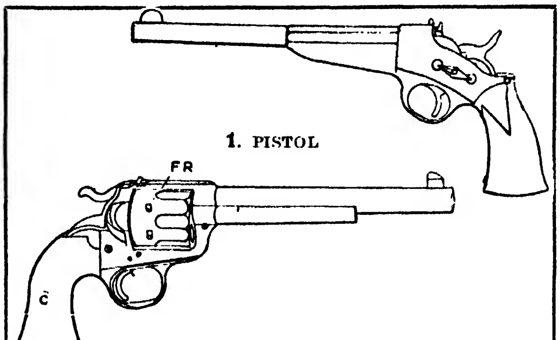
Webley's Revolver. The next advance was a double-action revolver invented by Adams, an Englishman, in 1855. The Webley [4] is a good modern example. In this type the revolving of the cylinder and cocking the lock is done by trigger pull, and therefore, after the first shot, each pull of the trigger fires a shot and brings round another cartridge.

The frame is made of a solid steel stamping, forged under a drop-hammer in recessed dies, and milled out to receive the cylinder and drilled. All the work is done by the clamp jigs and fixtures to gauges with a maximum and minimum allowance, usually about ·002 in. to ·004 in., depending on the requirements, and all the operations start from one face or point to ensure accuracy. The limbs are crucible steel stampings, machined all over in special jigs, by plain or finger mills or former mills. Each is tempered or case-hardened where required, and inspected and tested, and the holes lapped out and the sears adjusted, the holes being tested by plug gauges through plates to see that they are at right angles to the part.

The cylinder must be truly concentric with the axis pin and the chambers co-axial with the barrel and in line with the striker when the cartridge to be fired arrives at the upper position. This must also be assured by the latch engaging the corresponding recesses in the cylinder; moreover, the ratchet teeth on the back face must engage and disengage at the right moment, as must also the sears and bents, so that the motions synchronise. In others the barrel is swung down on a pivot below the axis joint pin, and the extractor is made to push out the cartridges. An extension of the barrel has a recess which is locked securely by a latch on the top of the frame. This locking gear must be well fitted.

The Nagant Revolver. The escape of gas between the forward face of the cylinder and the breech end of the barrel is one of the great

disadvantages of the revolver. Not only does this escape corrode the surrounding parts, but it diminishes the velocity of the projectile. This has been overcome in the Russian Nagant revolver by employing a long cartridge case which projects beyond the nose of the bullet. On cocking the hammer the cylinder is given a forward motion so that the end of the cartridge case enters the barrel, thus covering the gap between the cylinder and the barrel. A disadvantage of this system is that the work of pushing the cylinder forward, and so forth, is so heavy that it cannot be done by the trigger pull, and the weapon cannot be made on the "double-action" principle.

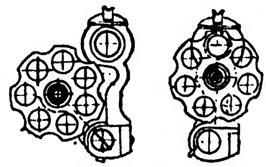


1. PISTOL

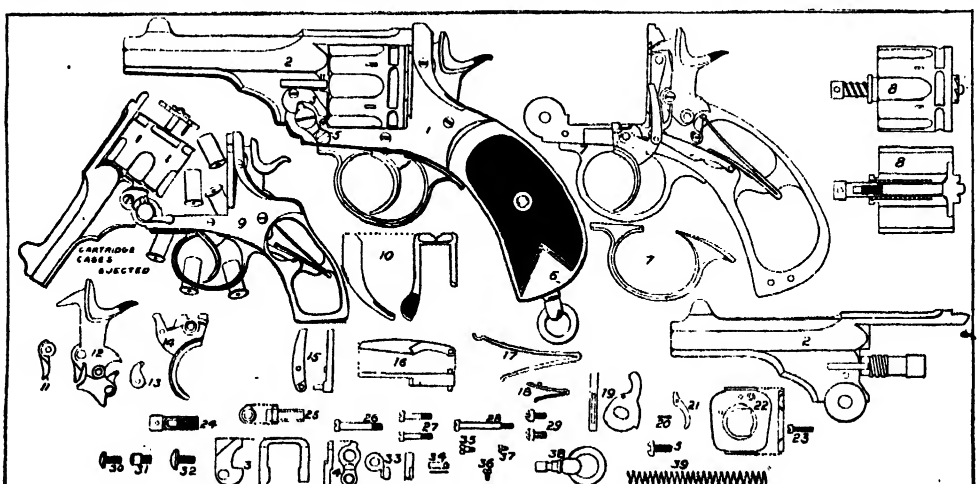
2. COLT REVOLVER

Automatic Revolver. A further development is the automatic revolver—such as the Webley-Fosbery, shown in **5**. It consists of a frame and handle that does not recoil, and a recoiling part composed of the barrel body with mechanism and cylinder attached. The body recoils on explosion, sliding in a groove in the frame, and is returned by springs actuating a lever; at the same time a fixed stud works in the zig-zag grooves that are cut in the outer surface of the cylinder. The cylinder is rotated by the fixed stud for half the movement, then the stud passes down the return groove, thus completing the movement.

The frame is a drop stamping, pickled in acid to clean off the scale; the flat side surface is then milled or shaped straight across the top horizontal grooves or slides milled out, and the hollowed stock is milled or wibbled out by former-recessing finger-mills. The main springs are forged from spring steel flats, which are put in groups in special fixtures and milled across, then bent to shape, oil-tempered and adjusted to correct weight by filling or grinding. The barrel is milled somewhat of hexagonal shape, with a solid foresight left on. There is a solid extension strap to the rear for locking, and a downward projection to form the axis pin joint. The barrel is first milled on the side flats, and faced and drilled and bored. The axis pin joint is faced, and milled out by section mills, and the holes are drilled through. The hole for the cylinder axis tube is drilled and bored. The barrel and its extension are milled to section, the extension radiused out to suit the cylinder, and the barrel is rifled and lapped out. The body stamping has a long, rectangular portion to form the sides, an axis pin joint projection at the fore end, and a triangular block at the rear with its apex upwards. This last, when machined, contains the action. The bottom slides are faced and grooved out by section mills. The thrust face is squared across and recessed for the hard steel shield, and for the rear of the cylinder extractor, and the various recesses milled out for the trigger, hammer, and so forth, to operate in. The cross pin holes are then drilled through a jig. The hard steel shield, after being



3. SWING-OUT CYLINDER OF COLT SERVICE REVOLVER



4. WEBLEY'S REVOLVER, MARK IV., DOUBLE ACTION

1. Body 2. Barrel and axis complete 3. Cylinder cam 4. Cam lever 5. Cam lever screw 6. Stock 7. Trigger guard 8. Cylinder and extractor complete 9. Cartridge cases ejected 10. Barrel catch 11. Hammer catch 12. Hammer complete 13. Hammer swivel 14. Trigger complete 15. Pawl 16. Main spring auxiliary 17. Main spring 18. Barrel catch spring 19. Extractor lever 20. Spiral spring, extractor lever 21. Extractor lever auxiliary 22. Shield 23. Screw, shield 24. Nut, extractor axis 25. Pin, joint axis 26. Screw, barrel catch 27. Screw, hammer and trigger 28. Screw, stock 29. Screw, guard 30. Screw, pin joint axis 31. Screw, cam 32. Screw, cam lever 33. Trigger stop 34. Trigger stop spring 35. Screw, hammer catch 36. Screw, hammer stop spring 37. Screw, hammer swivel 38. Butt, swivel 39. Spring, spiral

faced and machined outside and recessed, is hardened and ground true. The barrel catch is adjusted and fitted.

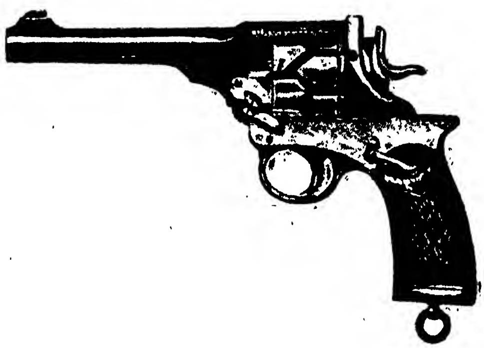
The handle and the trigger-guard form the non-recoiling portion of the revolver. The handle has long slides grooved out by section mills in its top table for the body to slide on, a recess cut out in front, and also a fixed pin to rotate the cylinder. The stock projecting downward is faced on both sides, and recessed out right through by former mills to contain the recoil-lever, which is fulcrumed at its lower end on a cross-pin. The stock also envelops the main spring and sear that hang downward from the sliding body. The trigger-guard forging is shaped out and fitted into the handle together with the trigger. The stock is recessed by former mills for the two vulcanite side-plates. The rear plate of the stock is machined to form a hinge at its lower ends to give accessibility to the recoil-lever. The vulcanite plates are pressed to shape in hydraulic presses, and fastened by screws on to the recesses provided in the stock. The cylinder is manufactured as previously described, with the exception that in the place of the rear ratchet-teeth the exterior is grooved, this being done by placing the bored cylinder on a mandrel, which is revolved, special revolving finger mills forming the grooves from a copy.

These grooves give the rotation to the cylinder when it recoils and returns with the body after each explosion. The action-limbs are machined in the same manner as described for revolvers. In assembling, it must be arranged that the slides and grooves work freely, but without jerk; the sears and bents are adjusted to engage and disengage correctly, so that as far as possible an even pull only is required on the trigger. The barrel and body, with the cylinder with the action attached complete, form a recoiling part when the axis-pin is inserted.

When assembled complete and ready for firing, the revolver becomes automatic, in that the trigger, on being pressed, trips a sear and releases a hammer. After the explosion the barrel and body recoil, cocking the hammer; the cylinder is rotated by the fixed stud passing down one groove, and completing its revolution, by passing down the other groove through the reaction of the recoil-lever moving the body forward again, thus bringing a fresh cartridge into the firing position, and leaving the body and trigger and hammer ready for firing. The parts are case-hardened and tempered where required.

Mauser Automatic Pistol. This is illustrated in 6. The barrel is a solid steel, stamped forging, with a round barrel and solid foresight, and a hollow, square extension forming the body, with two lower projecting lumps. The barrel is faced, and then drilled from end to end in a multiple drilling-machine; it is then milled across to square with the body. The rear part is slotted or milled across, and is then recessed through vertically between the breech and the body. The barrel is then draw-bored, and the interior of the body opened out to square section by shaper tools—like keyway slotters—and then to finished size by drawn drift-cutters. The barrel is finished, turned, and the foresight formed. The exterior is milled square, with projecting ribs left on the lower edges to slide in the frames. The bottom lumps [BL 1 and BL 2] are machined on the sides by gang-mills, and radiused for the bolt-lock L at the front end, and also between the lumps, forming an oblong recess, which is carried up right through the bottom of the body. This latter recess is for the bolt-lock to pass through. A slot to take the stop-block is slotted through the side walls near the rear end of the body.

Bolt-lock. This has a tooth-shaped crossbar at the front end to fulcrum around the front of B L 1. Two webs extend to the rear end, joining a rectangular block with two locking teeth on its upper edge, and two legs projecting downward. The rear legs rest on a supporting lug [S L] on the top of the lock-frame; and this leg, on recoil, slips down over the lug, the two legs straddling the lug and disengaging the locking teeth from the body. It is first milled on the outsides, and the recess wibbled out. The tooth is milled outside, and carefully inside, to form a fulcrum. The corners left by cutters are cleaned out so that it has a bearing right across.

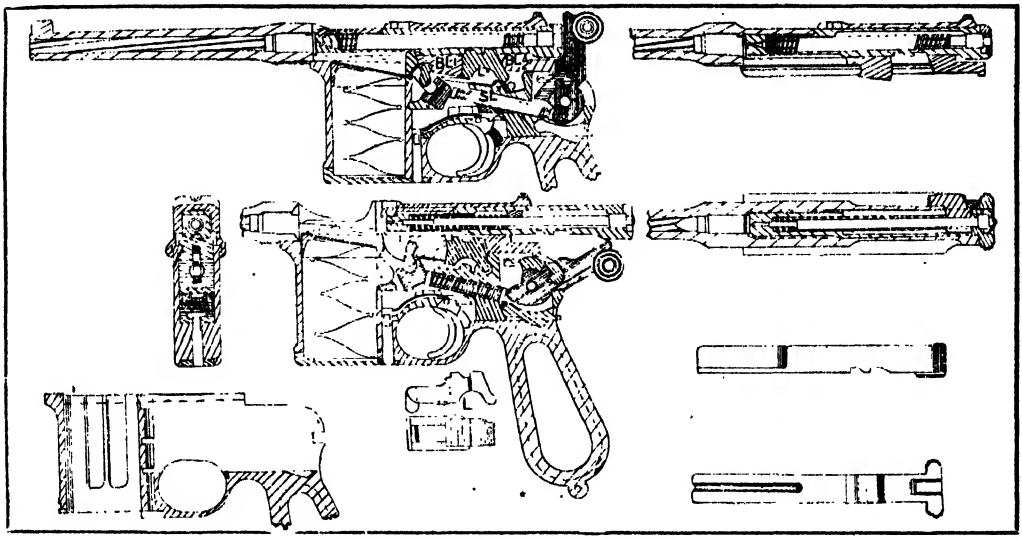


5. WEBLEY-FOSBERY AUTOMATIC SERVICE REVOLVER

Lock Frame. This is slid into the main frame from the rear. It is of somewhat rectangular shape, with two webs projecting to the front to embrace the knife-edge fulcrum upon which the rocker works; also, above this is a front-stop cross-member, which projects over the rear wall of the magazine. The main rectangular portion has a lug on the top face, and a bulb projection standing up at the rear, the bulb to form a stop for the bolt-lock, and a flat top over which the body slides. The rear of the block is recessed out to form the cheek-joints for the hammer to work between. The whole is secured in position by a rear stop-block pressing into a groove in the frame and recess into the main frame, and held down by a vee-spring.

The stamping is first faced parallel on the sides, and on top and bottom. The cheeks are milled out, leaving a rear crossbar. The hammer axis pin-hole is drilled through a jig. Then the front face of the fulcrum-bar and the knife-edge of the same are shaped, and the hole for the main spring is drilled out relatively to the axis-pin. The top lug, the recess for stop-block, and the recesses for lever and sear on one side are all machined to gauges, using the axis-pin and bottom and side faces as "spotting" points.

Main Frame. The main frame is a steel stamping. It has two projecting outside top slides and one inside, hollow, deep, oblong sides to contain the magazine in front, and also the lock-frame in rear, and it is continued down to form the stock and trigger-guard. The stamping is first faced on the top table, then milled to section outside, to form the guides and faces; also the stock. The interior is drilled out with relief holes, and

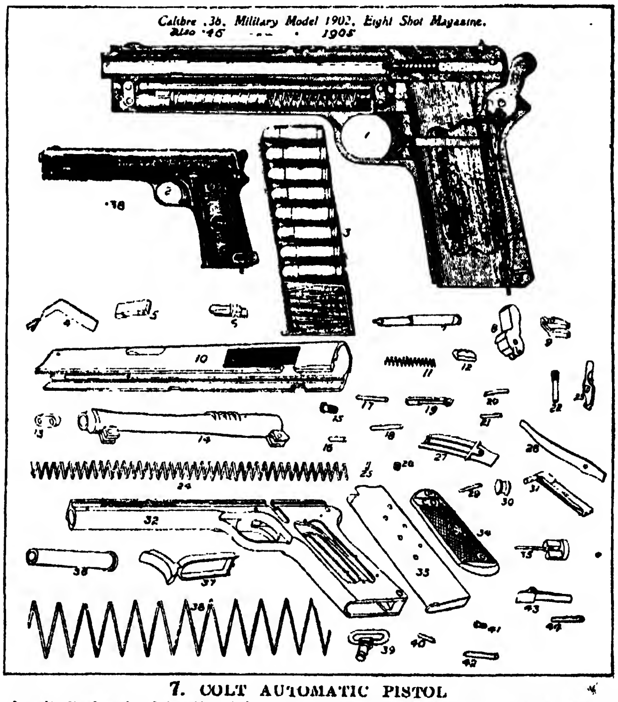


6. MAUSER AUTOMATIC PISTOL

opened out by former mills. The stock is recessed right through, except where rebated for the vulcanite side-plates, and is machined out to form the trigger-guard.

Action. The hammer is a stamping. After facing, the axis pin-hole is drilled, and the faces and edges are milled to template. The front projection forms the sear-bent, and the lower projection is left to press against the main spring plunger. The circular finger-grips are knurled. The action is then adjusted, hardened, and fitted.

The rocker is of hook shape, to engage the tooth projection of the bolt-lock. It has a round face, on which the main spring plunger acts. An axis-pin is driven in to form gudgeons. It rests on the knife-edge of the fulcrum when the barrel is home, but is turned over and forced back against the main spring on recoil, by the bolt-lock tooth. In manufacture it is made, in some cases, from a rolled section sawn across to length, and is then faced and the pin-hole drilled. It is hardened on the hook-point and fulcrum face.

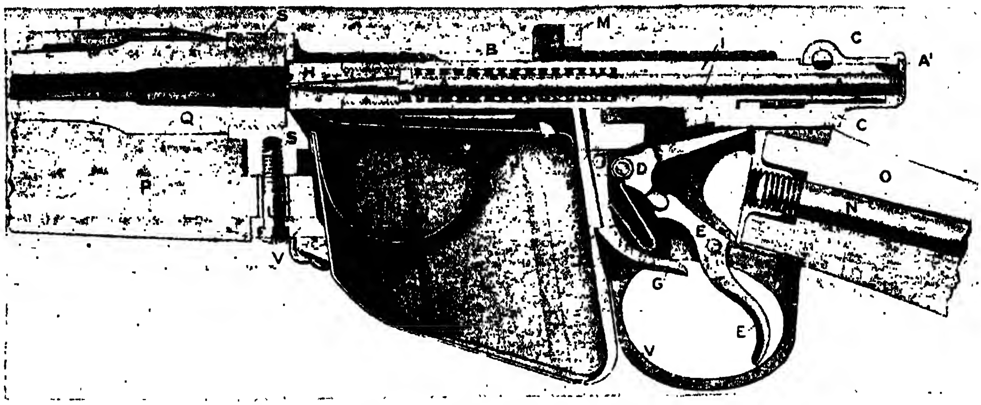


7. COLT AUTOMATIC PISTOL

1. Longitudinal sectional elevation 2. Side elevation, assembled 3. Magazine loaded 4. Magazine follower 5. Slide lock 6. Slide stop 7. Firing pin 8. Hammer 9. Sear 10. Slide 11. Firing pin spring 12. Rear sight 13. Links 14. Barrel 15. Main-spring screw 16. Link pin, short 17. Firing pin lock pin 18. Sear and safety pin 19. Shell extractor 20. Shell extractor spring 21. Shell extractor pin 22. Hammer screw 23. Safety 24. Retractor spring 25. Hammer roll pin 26. Hammer roll 27. Sear, safety and trigger spring 28. Main spring 29. Ejector pin 30. Recoil plug 31. Ejector 32. Receiver 33. Magazine 34. Scales (2), right and left hand and escutcheons 35. Plug (take down) 36. Follower 37. Trigger 38. Magazine spring 39. Swivel 40. Swivel pin 41. Scale screws (4) 42. Plug and link pin, long 43. Magazine catch 44. Magazine catch pin

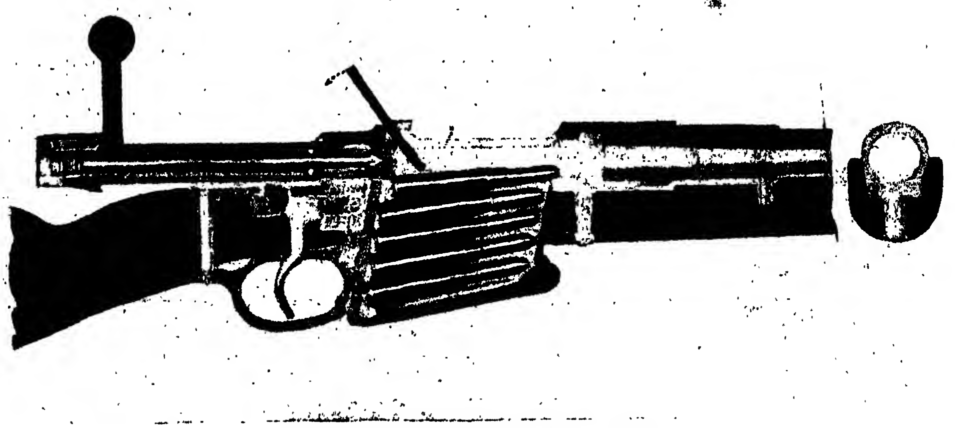
The Bolt. The bolt is milled square in section outside, bored from end to end in a multiple-drill press to contain the striker and its spring. It has a long slot in the right-hand side, through which the buffer-stop to the spring is inserted. The fore end has a plug inserted with a taper-hole to contain the striker and its rebound spring. The rear end is also bushed, and the striker pinned in. The rear end has knurled horns for grasping when required to pull back by hand, to cock the lock at the start, or to fill the magazine. The notches are milled across the under side. In these the bolt-block teeth engage and disengage. A long, V-shaped groove is milled on the under side for some distance from the front end. The top front has a recess and holes to bed in the extractor; the latter is a spring-tempered hook. The striker is of high grade, round-section steel, and is turned down in

THE DELICATE MECHANISM OF MODERN RIFLES

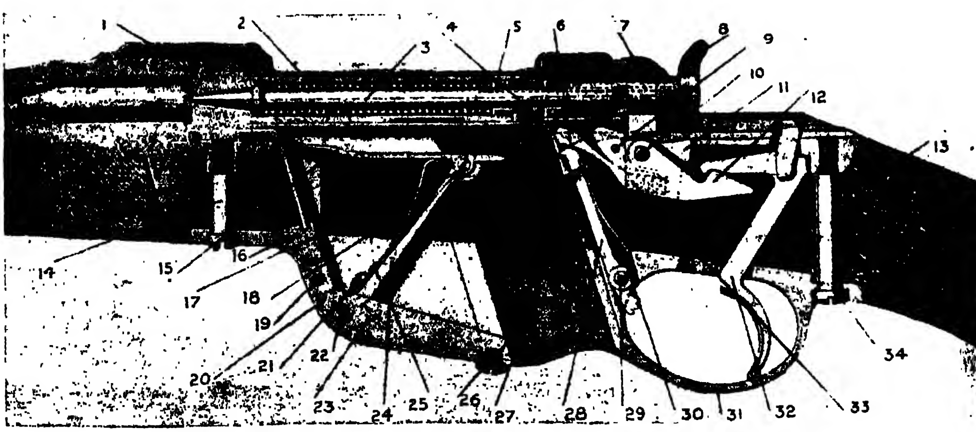


8. THE MECHANISM OF THE LEE-ENFIELD RIFLE

A. Striker. A1. Striker pin retaining screw. B. Striker spring. C. Cocking piece. D. Sear piece. E. Trigger. F. Trigger and magazine catch spring G. Magazine catch. H. Bolthead. I. Bolt. J. Magazine platform. K. Magazine platform spring. L. Magazine. M. Charger quire. N. Stock retaining-bolt. O Stock. P Fore end O. Knox forme R. Chamber. R1. Lead. R2. Bore. S. Body. T. Handguard. U. Action screw. V. Trigger guard and under frame.



9. THE MAUSER RIFLE MECHANISM



10. THE MECHANISM OF THE STRAIGHT-PULL MANNLICHER RIFLE

1. Body. 2. Bolthead. 3. Striker. 4. Groove for turning feathers. 5. Bolt. 6. Ejector. 7. Cocking piece. 8. Safety. 9. Ejector pivot. 10. Sear pivot. 11. Bent. 12. Sear body. 13. Hold through stock. 14. Forward magazine and guard screw. 15 Cartridge elevator. 16. Magazine and trigger guard (in one piece). 17. Platform pivot. 18. Platform spring. 19. Magazine trough screw. 20. Magazine trough. 21. Platform spring retaining screw. 22. Cartridge elevator pivot. 23. Elevator spring. 24. Elevator. 25. Platform spring adjusting screw. 26. Elevator spring retaining screw. 27. Clip catch spring screw. 28. Clip catch. 29. Clip catch pivot. 30. Clip catch spring. 31. Magazine and trigger guard (in one piece). 32. Trigger. 33. Ejector spring. 34. Rear magazine and guard screw.

a rod-feed, hollow-spindle lathe, and the point subsequently tempered.

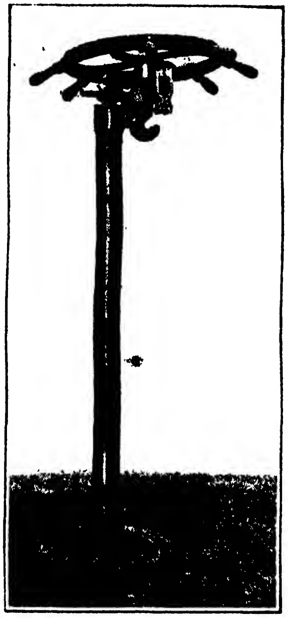
Another very good type is the Colt automatic pistol [7]. Its manufacture need not be described in detail. Complete sectional views are shown in the figure, and a list of the component parts is given. It is adopted in the United States Service.

Another automatic pistol of this type is Browning's Patent, which is used by the Belgian police. The Webley Automatic has been adopted by the Metropolitan Police. A Webley Semi-Automatic, firing ·22 cartridges, is also manufactured for gallery practice.

Military Rifles. Most of the modern military rifles have the door-bolt type of breech, and steel barrels, fitted with walnut stock, the cartridges being fed up from a magazine carried below the butt and in front of the trigger guard. Typical of this class are the Lee-Enfield [8] and the Mauser [9], the former being used by Great Britain, and the latter by Germany, Belgium, Spain, Turkey, and other countries. The Mannlicher [10], as used by Greece, Holland, and Italy, is another example of the prevailing type.

The chief difference in the breech-locking is that the lugs in the Mauser are at the front of the bolt and close up to the barrel, whereas in the Lee-Enfield they are at the rear, which some hold is bad practice, as the pressure tends to spring the bolt on an excessive pressure obtaining; moreover, as a long pillar practically unsupported, it is mechanically weaker.

The Lee-Enfield Rifle. The number of component parts of the Lee-Enfield is much in excess of the Mauser or Mannlicher, but it has come out fairly satisfactorily through severe campaigns. The barrel is made from either "high carbon" or "mild" steel. It may be rolled, as at Enfield, from a round bar of suitable dimensions through a series of ten pairs of rolls arranged alternately vertically and horizontally, which elongate the barrel and taper it in transit, all in one heat. The work put on the barrel materially improves its capacity for standing the strain of the explosion. It is also claimed that this method enables the barrels better to retain their straightness during the drilling and following operation. But satisfactory barrels are also obtained by the use of the "Ryder hammer," which consists of a number of pairs of semi-circular dies graduated in size, the upper of which are caused to move rapidly up and down by eccentrics.


11. BARREL-STRAIGHTENING MACHINE

After this process the enlarged breech is stamped by steam or power hammers between top and bottom dies. The barrels are then cold straightened, either in rolls or in the machine shown in **11**. They are then spun on centres, and finished, straightened by hand hammers very rapidly by experts, turned and clamp milled; that is, by revolving cutters to gauge sizes in three places. These turned portions are called spotting points, the subsequent taper-turning work having reference to them; the ends are faced and centred, and afterwards drilled in a special drilling machine. In the older practice, which is much followed, the barrel is drilled from both ends at the same time, the barrel being revolved at about 1000 revolutions per minute, half-round bits being used, and at the same time a copious supply of soapy water being pumped at high pressure on to the cutting face through small brass tubes, carried along with the bits, thus washing the turnings out backwards, and also keeping the bits cool. The bits are made to vibrate to clear out the swarf more effectually. On arriving near the centre the operation is completed by one set of drills. In later practice, however, the barrel is drilled from end to end in one operation only.

Draw boring follows this operation with a three-cornered bit of short length, the barrel revolving at low speed. It is again set as required. The barrel is then further turned, using the two spots at the ends and others in the centre, by several cutters or tools, the barrel being spring-supported by back rests; these latter, and the cutters, traversing the bed automatically, copy the taper or shape required from a fixed tangent bar.

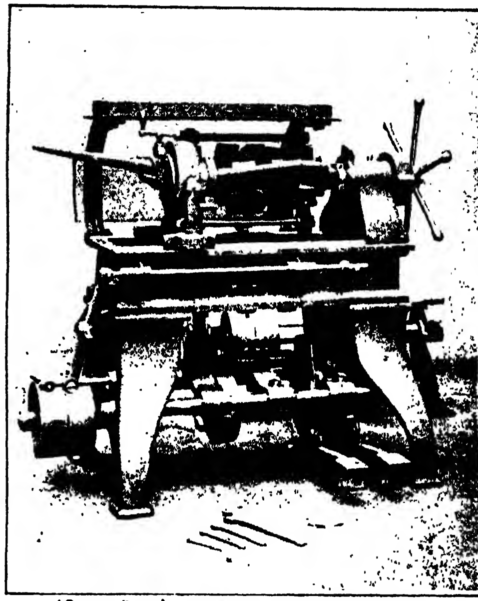
After rough turning, the barrels are straightened by the barrel setters. In the old method the setters place the barrel at an angle with the muzzle towards a window with a horizontal board in its top pane, and, looking through the bore, observe any irregularity of the "shade" or shadow that is cast on the bottom of the bore. They then place the tube or barrel across a hollow anvil, and give blows with a curiously shaped hammer. In the sighting and setting the men acquire marvellous dexterity, and are able to make the barrels absolutely straight in bore. The modern method depends on the observation on the multiple reflection of the muzzle, the setting being done mechanically [11]. The barrel is fine bored with a square bit, one or two corners of which are kept from touching the bore by wooden spills. Packings are inserted between the spills and the bar, to compensate for the wear of the cutting edge of the bit. The barrels are now second turned and polished, and are then ready for rifling, and again set. Furthermore, they are now tested in a machine for truth of bore, and any want of truth is indicated by the long arm of a lever of bell-crank shape; the short arm rests in the bore of barrel, which is spun on a tension mandrel.

Rifling. The usual method of rifling [8 R²] adopted in England is the old single hook cutter method. In the machine [12] the tool, when passing up the bore, is drawn in like a cat's claw, and then, being drawn out towards the muzzle, the hook tool cutter is pushed out. Each separate groove is thus cut or planed out to the required depth in the bore, while at the same time the required twist is given, in some cases by a fixed tangent bar, which causes a rack to traverse across the slide rest. In doing so its teeth engage those of a pinion attached to the rifling bar, thus causing it to revolve and in this manner to produce the required twist.

Other methods adopt a tail rod—that is, a continuation of the rifling bar, having grooves with a twist identical to that required to be produced in

the barrel. Each groove engages a white metal stud, which causes the tail rod to revolve, and thus directly imparts motion to the rifling bar. With its cutter box each groove is planed out separately, and its relative position to the next groove is guaranteed by advancing one notch of the division plate at the end. The rifling tool, or cutter box, is shown in detail [16], and will be described. Oil under high pressure is continuously pumped through a small tube on to the cutter; the shavings as they are drawn back are examined by the rifler, and form a good criterion as to the state of the cutter and the inside work. Great care must be taken not to tear the grooves, but to get a clearly planed-out cut from end to end.

Rifling Head Cutter Box. In this machine [16] the hooked cutter C at the end is solidly backed up by stop plunger P when cutting. The depth of the cut is regulated by screw adjustment, A, and an incline plane, I, up which the cutter is pressed by the spring S acting on its tail end. It will be seen that when making idle strokes up the bore the cutter is pushed down against the spring, but when returning on the cutting stroke it is pressed out again to the stop P. Other countries use drift cutters following each other through the bore with quick, light feed, each drift following closely to the other. After rifling, the barrels are lapped out with lead laps in a lapping machine, and then pass to a polishing machine, which takes the grooves. Finally, a high revolving cylindrical lap finishes the *lands*—that is, the projections between the grooves. The thread of the breech end is then



13. LOËWE'S STOCK-TURNING MACHINE

on the breech end with a touch-hole through it, and returned duly stamped if correct. The barrel is then chambered to suit the cartridge.

MAGAZINE RIFLES USED B. VARIOUS GOVERNMENTS

Country	Austria, Bulgaria, and Greece	Great Britain		France	Germany	Japan	U.S.A.
Pattern of the year	1895	1907	1907	1886	1898	1900	1903
Designation	Mannlicher	Lee-Enfield Charger Loading	Short Lee-Enfield	Lebel	Mauser	Year '38	Short Magazine
No. of cartridges in magazine	5	10	10	Tube Magazine 8	5	5	5
Weight:							
Without bayonet	8 lb. 5¼ oz.	9 lb. 4 oz.	8 lb. 10¼ oz.	9 lb. 3¼ oz.	9 lb.	8 lb. 9¼ oz.	8 lb. 8 oz.
With "	8 lb. 15¾ oz.	10 lb. 3¼ oz.	9 lb. 10¾ oz.	10 lb. 1½ oz.	9 lb. 14 oz.	9 lb. 8½ oz.	9 lb. 8 oz.
Length:							
Without bayonet	4 ft. 2 in.	4 ft. 1·5 in.	3 ft. 8·5 in.	4 ft. 3·12 in.	4 ft. 1·4 in.	4 ft. 2·5 in.	3 ft. 7·212 in.
With "	4 ft. 11·5 in.	5 ft. 1·5 in.	5 ft. 8·7 in.	5 ft. 11·84 in.	5 ft. 9·75 in.	5 ft. 5·5 in.	4 ft. 11·212 in.
Barrel:							
Length in.	30·12	30·19	25·19	31 496	29·05	31·3	23·79
Calibre in.	·315	·303	·303	·315	·311	·256	·30
Muzzle velocity	2034	2060	2060	2073	2882	2390	2600

Mauser also used by Belgium, Spain, Turkey, and Brazil. Mannlicher also used by Rumania, Holland, and Italy.

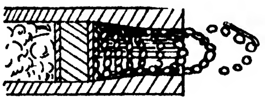
cut and rectified, and the barrel finished outside, cut to length, and the muzzle end finished. The barrels are then sent to proof with a screwed plug

12. RIFLING MACHINE FOR R.C. GUNS

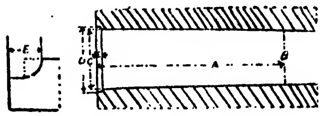
The barrels are then browned. To do this they are first plugged at both ends, boiled in soda water, and covered with lime, then dried, and then immersed in a heated acid mixture and rusted, then scratch brushed. This treatment is repeated till an even surface is obtained. The barrel is then dipped into a bath of soft water with alkali to kill the acid, then cleaned off, and polished. The resulting surface is now practically rust-proof. The bolt and other components are also browned. After tapping for the sight-bed screws, and various inspections, the barrel is ready for sighting. The barrel is adjusted, and the sights fitted on and tested, then breeched up, and it must be correctly in line; also, when the barrel

is screwed up dead home the sights must be absolutely vertical.

Action Body. The body [8 S] is made from a special mild steel, which is first broken down roughly to shape from the bar, and then stamped, after which the fins or extruded metal are cut off. The forging is then box-annealed in charcoal for half a day, after which it is pickled and placed in a dilute acid bath, which cleans off the scale. It is now ready for the various machining operations.



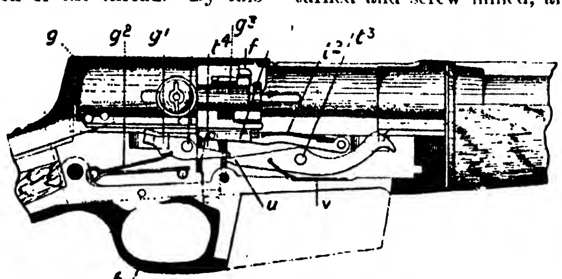
14. DIAGRAM OF EFFECT OF CHOKE BORING ON SHOT



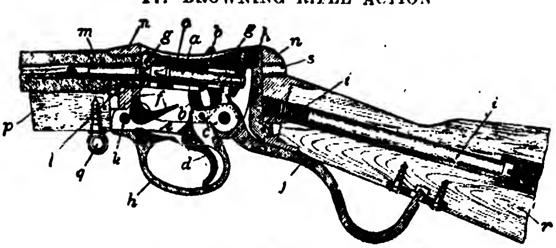
15. MINIMUM CHAMBER DIMENSIONS

The body is first faced at both ends, then centred, and the breech face and the body drilled for the bolt hole in a multiple drilling machine; this hole is then drawn and fine bored. The hole in the socket end is drilled and tapped, in a jig or fixture. The recess for the breech screw is now opened out to the tapping diameter. It is then tapped in an automatic thread-milling machine. The work is held in a special chuck, and a milling bob is rapidly revolved, cutting into the bore to the full depth of the thread. The chuck portion with the work makes one revolution, but during this revolution it also has a longitudinal travel imparted to it by cams, equal to the pitch of the thread. By this means the whole of the thread is obtained. The machine has all its motions instantaneously arrested on the completion of the revolution by automatic gear. The face is then milled off accurately. The thread and face, together with the bolt hole, and with the tapped hole in the socket end and a flat face that is milled on for the tongue, form the spotting points or working faces, which enable the subsequent operations to be carried out relatively to them in the numerous jigs and fixtures.

16. RIFLING MACHINE CUTTER BOX HEAD



17. BROWNING RIFLE ACTION



18. MARTINI ACTION DIAGRAM

a, striker; *b*, indicator; *c*, tumbler; *d*, trigger; *e*, trigger-spring; *f*, extractor; *g*, block or bolt; *g1 g2 g3*, bolt retaining and operating mechanism; *h*, trigger-guard; *i*, stock-bolt; *j*, lever; *k*, guard-keeper screw; *l*, barrel-locking bolt; *m*, barrel; *n*, body; spring; *p*, fore-end; *q*, fore-end swivel-eye; *r*, butt; *s*, cleaning-rod hole in body; *t1 t2 t3 t4*, cartridge feed mechani[sm]; subsiding action spring.

The body in suitable fixtures is now passed to the various milling machines, the slides and various recesses accurately milled out to the correct contour and depth by former or profiling mills. Generally the latter consist of two overhung spindles on a vertical slide, parallel and connected to each other, one having at its lower end a pin or stylus, and the other having cutters. With this arrangement and that of the freely moving longitudinal transverse slides on the machine, any template or former fixed alongside the work will be copied, by the cutters or mills grooving out the solid metal as required. In addition to this some of the jigs allow the work to swing to cut out radial recesses or slides, and in others an end-on movement is given to form the helical recess for the locking lug. The body is hardened at the recoil shoulders. The stamping in its finished state weighs only about one-fourth that of the original, showing the large amount of machining done to this part alone. The action limbs are stamped out of high-grade steel and machined.

Bolt. This [8 I] is of crucible steel, and is stamped hot, and the handle set, finned, and then pickled to clean any scale off. It is then faced on both ends and turned where possible, and the knob milled. The ribs, etc., are milled, and it is then drilled through to contain the striker, then finished milled. After one hundred detail operations, the bolt is hardened and tempered and straightened.

Bolt Head. The bolt head [8 H] is made of special gun-iron; it is a forging in most cases. After the facing and milling of the faces, the striker hole is gradually opened out and coned, the stem turned and screw milled, and the various recesses milled and slotted out. There are sixty operations. The head is then hardened, the screwed part being protected by fireclay.

Stocks. The stocks are of European walnut well seasoned, and without defects. The blocks are rough sawn to shape and turned in a copying lathe by revolving cutters, as shown in 13, and grooved out for the barrel, magazine, and so on. In the case of the Mauser, the stock is in one piece, but the English rifle is divided into two parts, the butt and fore end [8 O and P].

The barrel and body with bolt-head and action are now placed in a carriage for final proof, and the compression of a copper crusher-gauge in rear of the cartridge head referred to, a known deflection of a similar copper cylinder, enables the maximum pressure on the base to be obtained. If correct, the parts are then proof stamped. The whole is now assembled on the stock, examined, adjusted, and tested on the range.

The Mannlicher and Mauser bolt and action are much simpler, and can be stripped by hand in a few seconds. They are also much simpler for

manufacture than the Enfield, and the bolt stands up to the work better. Recent experiments have shown that they will sustain pressures very far in excess of that for which they are used.

The table on page 2507 gives full particulars of the magazine rifles used by various Governments. The tendency now is to make a lighter bullet, by decreasing the weight of the lead interior towards the nose, or by decreasing the calibre of the rifle, but should an absolutely reliable automatic rifle be produced, it would no doubt be adopted, if the difficulty of ammunition supply in the field can be overcome. The best military rifle at present manufactured is the 7 m.m. Mauser with which the Brazilian Army is provided. It shoots a light bullet with a velocity of over 2900 feet per second.

The Miniature Rifle. The great extension of the Rifle Club movement during recent years has made the ·220 calibre, or "miniature" rifle, a weapon of considerable importance in the gun trade.

THE LEWIS GUN BEING FIRED FROM AN AEROPLANE

The ·220 rim-fire cartridge is of American origin, and the first ·220 rifles came from the United States. They have hammer action, usually of the sliding or falling block, lever operated type, and though somewhat roughly finished were excellent in their shooting qualities. Some of the American patterns, such as the Stevens, Remington and Winchester, are still used in this country.

The great popularity of the ·220 calibre rifle was made possible by the perfecting by W. Greener, the well-known gunsmith, of a system of converting the old Martini-Henry Service rifle into a miniature rifle by substituting a ·220 barrel for the old ·450 bore barrel. This conversion presented several technical difficulties, the chief of which was that the Martini action was designed so that the striker would impinge vertically on the cap in the base of the cartridge. The construction of the cheap and reliable ·220 cartridge (which had already established its reputation) necessitated that the striker should impinge on the rim of the cartridge, the edge of the chamber being used as an anvil. In the converted rifle Greener overcame this difficulty by boring the barrel excentrically so that the axis of the barrel and the axis of the bore were not coincident. These converted rifles are sold for 24s. or 25s. through the National Rifle Association or the Society of Miniature Rifle Clubs. Most of the conversions are made by Birmingham gunmakers.

During the last five or six years a large trade has grown up in specially designed ·220 rifles made with the sole idea of giving the utmost perfection in target shooting. The B.S.A. ·220 rifle, in its various forms, is a good example of these special target rifles. The action is a small, modified Martini, so arranged that by the removing of a single thumbscrew the whole action can be removed in one piece for cleaning or examination. At the same time a hole in the rear of the action body is exposed, and permits of the barrel being cleaned from the breech end.

Automatic Rifles. The true automatic rifle, in which the mechanism is made to eject the fired case, load in a fresh cartridge, and cock the action by utilising the forces generated by the explosion of the cartridge, is looked upon by military experts as the small-arm of the future. There are several types now on the market, some well and some ill fitted to the dangers and difficulties of active service work, but the opinion seems to be that there is not yet extant a weapon so near the ideal as to warrant any nation arming her troops with it.

Automatic rifles are designed on one of two principles. Either the work of ejection, reloading, and so on, is done by the force of the recoiling barrel, which, coming back on a fixed part, as in the automatic pistol, operates the mechanism, or some of

the gases generated by the explosion are tapped some distance from the muzzle, and the force is utilised to drive back a piston which acts as the ejector and loader. The first type are known as *gas operation* and the second as *recoil operation* automatic arms. It is usual in automatic rifles to so arrange the action that the trigger has to be pulled to fire each shot. In weapons of the Maxim or Lewis machine-gun type the contrary is the rule, and the weapon continues to fire as long as the trigger is kept pulled back and there is ammunition [25].

One of the chief problems that has to be solved before the automatic rifle can become the standard military small-arm is that of securing an adequate supply of ammunition on the field.

Sporting Guns. Sporting guns are made in great variety, and include single and double barrel shot guns, smooth bore, also rifled express guns. Today they are chiefly hammerless breech-loaders.

The smooth-bore barrels are made from either (1) twisted and welded Damascus type, or (2) high-grade steel of special quality. The Damascus barrels have a beautiful pattern upon them, due to an arrangement of iron and steel twisted bars; the steel of these, when acted upon by acid, remains light colour and the iron brownish. The effect is produced by first piling the iron and steel alternatively with a larger proportion of steel for strength, then by rolling the same into rods, preferably of square section. In the English Damascus type three rods are taken; each is twisted on its own axis and then rolled together in a mill to the form of a ribbon. The ribbons are then coiled by gearing over a loose corebar. The coils are then brought to welding heat and welded around a mandrel by hammering. The thicker coils are then interlaced or scarped on the muzzle portion of the barrel, and the whole is drawn out to the required thickness and the protruding metal is cleaned off. It is to be noticed that the metal must be kept free from scale.

The resulting pattern in this type is that of a chain of interlocked circles. This type of barrel is now being rapidly superseded by the weldless steel tube, which is more suitable for the modern nitro powder and the gun of the hammerless drop-down type with double extraction.

In shot guns the tubes may be drilled, drawn down, or of drawn tubes, or forged out of the solid and drilled, as in express rifles. The usual methods of boring are somewhat similar to those described under rifle manufacture.

The latest practice is to drill through the bar of steel from end to end (instead of from each end and meeting at the centre) with a Loewe drilling machine, and finish the boring in one process, any straightening being done mechanically or by hand setting. These tubes are then finished by the gun-maker, and finished bored or choked to his special requirements.

The outsides are not turned, but ground true by hand. Also, in addition to this, many barrels are choke bored. In choke boring the muzzle is contracted to concentrate the shot, and give a denser "killing circle." This is done by finishing the bore at the muzzle end with special tools of smaller diameter than the main bore, but some makers contract the muzzle by dies in the hydraulic press. The effect of this choking is shown in the diagram [14]. The bores are lead lapped out to get a fine polished surface. The tubes are subjected to a provisional proof to test the barrel, and afterwards to a definite proof.

In double-barrel guns the tubes after proof are assembled and fitted together by the barrel filer with their ribs, lumps, and the like. The top and bottom ribs are fitted and jointed up, the inner edges of the barrels being filed so that they converge. The top ribs may be fluted or shaped as desired. The breech lumps and wedge pieces are brazed on. The breech body, already machined, is now fitted on.

The jointing up of the breech is an important item in drop-down guns, and these parts are filed and scraped to fit together in the most careful manner. The holes and ends must also be dead square, so that all parts transmit the shock to the fixed breech, but at the same time the gun must open freely and with regularity. The locking bites must be tight with no slogger. The extractors, which have usually two legs, are fitted in to work freely, and the end faces when home must not project beyond the breech end of the barrel.

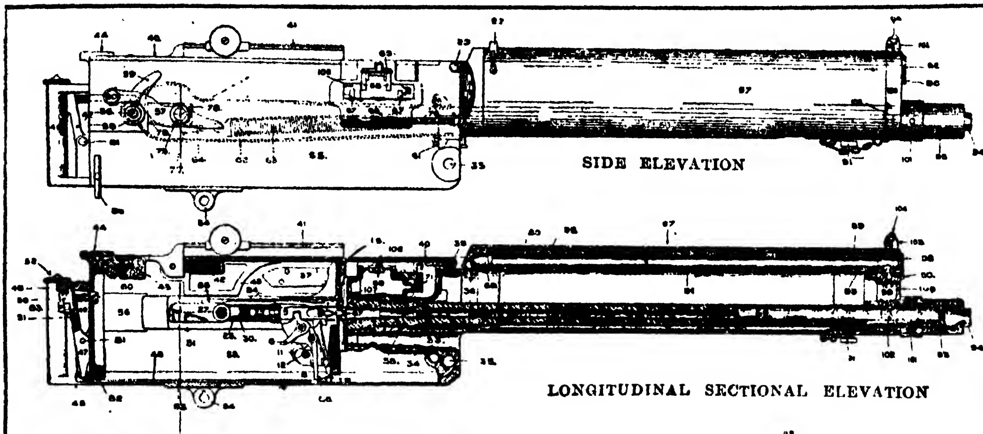
The breech body is usually made from a solid forging with front or fore-end projection, a flat, squarish part for the mechanism (action). This block is machine recessed for the mechanism, but in many cases two side lock plates are fitted to carry the lock mechanism.

There are a great variety of extractors and ejectors; many of these are actuated by the fore end, which cases the cartridge case and flips it out completely when clear of the standing breech. At the same time the mechanism cocks the hammer. In all cases the striker must be clear of the barrel face before the gun is opened out.

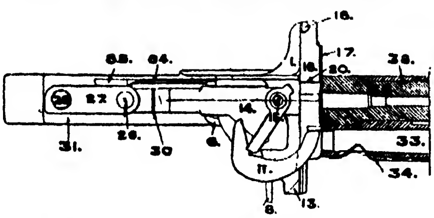
The body fore end and action and lock plates are hardened in animal charcoal, or the steel action components are hardened and tempered by gas-muffle furnace by the aid of oil and water hardening. The walnut stocks are sometimes shaped (as

TABLE OF MINIMUM SHOT-GUN CHAMBER SIZES

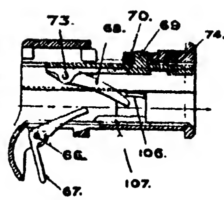
Bore of Gun*	Mean Diameter of Wadding	Length of Chamber A.		Depth of Rim B.	Length of Chamber Taper A-B.	Diameter at Front	Calculated Taper.	Size under Head		Size of Head	Radius of Rim Circle
		Nominal.	Decimal.					For Gauges	For Chambers		
4 (·935)	948	4 in	4·000	·130	3·870	1·035	(Does not apply)	1·0900	1·090	1·200	030
8 (·835)	·845	3¼ in	3·250	·115	3·135	·914	015675	9297	·930	1·035	·020
10 (·775)	·784	3¼ in.	3·250	·074	3·176	·845	·015880	·8609	861	·933	·020
10 (·775)	784	2⅞ in	2·875	·074	2·801	·845	·014005	·8590	·859	·933	·020
12 (·729)	738	3 in.	3·000	·074	2·926	·800	·014630	·8146	·815	·886	·020
12 (·729)	·738	2¾ in	2·750	·074	2·676	·800	·013380	·8134	·813	·886	·020
12 (·729)	738	2½ or 2 9/16	2·560	074	2·486	·800	·012430	·8124	·812	·886	·020
14 (·693)	·702	2½ or 2 9/16	2·560	068	2·492	·763	·012460	·7755	·775	847	·020
16 (·662)	·671	2¾ in.	2·750	·062	2 688	·752	·013440	·7454	·745	·815	·020
16 (·662)	·671	2½ or 2 9/16	2·560	·062	2·498	·732	·012490	·7445	·744	·815	·020
20 (·615)	·623	2¾ in.	2·750	·060	2·690	·685	·013450	·6985	·698	·766	·020
20 (·615)	·623	2½ or 2 9/16	2·560	·060	2·500	·685	·012500	·6975	·698	·766	·020
24 (·579)	·587	2½ in.	2·500	·060	2·440	·649	·012200	·6612	·661	728	020
28 (·550)	·557	2½ in.	2·500	·060	2·440	·614	·012200	·6262	·626	·688	·020
32 (·502)	·509	2½ in.	2·500	·060	2·440	·562	·012200	5742	·574	·636	·015
410 (·410)	·415	2½ in.	2·500	·060	2·440	·465	·012200	·4772	·477	·537	·015
360 (·360)	·363	1¾ in.	1·750	·050	1 700	·415	·008500	·4235	·424	·479	·015



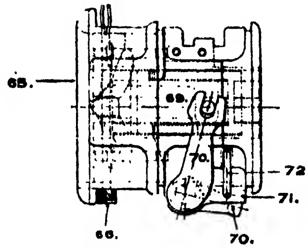
19. MAXIM AUTOMATIC R.C. GUN



20. LOCK OF AUTOMATIC R.C. GUN



21. FEED BLOCK OF AUTOMATIC R.C. GUN (SECTION)



22. FEED BLOCK OF AUTOMATIC R.C. GUN (PLAN)

described in rifle manufacture), but in sporting guns most of the stocks are varied in length, set, and shape to suit the balance of the gun and the purchaser. They are highly finished and polished; also, the gun may be finally decorated by engraved lines. A list of the approved minimum dimensions for various gun chambers is shown in the table from "Arms and Explosives" at the bottom of preceding page, which refers to the dimensions of **15.** The taper in all cases is ·005″ per inch in length.

A recent development in gunmaking is the resuscitation of the "under and over" pattern, in which one barrel is placed on top of the other. This system undoubtedly gives many advantages, but one of the difficulties is the placing of the trigger and ejector mechanism. Several patents for under and over action have recently been granted.

Maxim Automatic Machine Gun. It is necessary to explain that this gun is fully automatic—that is to say, after firing the first shot the explosion causes the barrel and lock to recoil together and the following cycle obtains. The empty case is withdrawn from the barrel at the same time that a loaded one is pulled out from the belt. The barrel returns home again, causing another loaded cartridge to be brought forward in the belt, into the feed box, by moving the belt. But the lock continues its rearward course, cocking the lock; and, coming forward again, raises up and inserts the loaded cartridge into the barrel, seizes another full one in the belt, having ejected the empty case; and, lastly, when the breech is quite securely home, the trigger is tripped, releasing the firing pin, and again firing the gun. The recoiling parts of the gun are brought back by a strong fusee spring situated at the left-hand side of the gun. That the reader may follow out the action of the gun, and so become acquainted with the various parts, we reproduce drawings [**19** to **23**] furnished by Messrs. Vickers, Sons, & Maxim. Each part is numbered on the drawings, and the names of the parts to which the numbers relate are as follow.

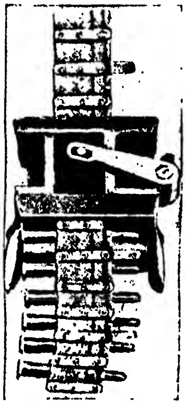
1. Lock casing 2. Safety sear 3. Sear spring 4. Sear axis pin 5. Firing pin 6. Tumbler 7. Tumbler axis pin 8. Trigger 9. Trigger axis pin 10. Lock spring 11. Extractor levers 12. Axis of extractor levers 13. Lower extractor stop. 14. Side levers 15. Side lever axis pin 16. Extractor 17. Cartridge grooves 18. Horns of extractor 19. Upper extractor stop 20. Notch for extractor holding up spring 21. Gib 22. Gib spring 23. Gib cover 24. Extractor spring 25. Connecting rod 26. Crank pin 27. Crank 28. Crank shaft 29. Connecting rod nut 30. Washer for connecting rod 31. Recoil plate 32. Barrel 33. Ejector tube 34. Ejector tube spring 35. Crosshead joint pin hole 36. Trunnion block 37. Inside cam 38. Cannelure for asbestos packing 39. Cover joint pin 40. Cover 41. Tangent sight 42. Tangent sight spring 43. Cover block 44. Cover lock 45. Cover lock spring 46. Rear crosspiece 47. Firing lever 48. Trigger bar 49. Firing lever spring 50. Double button on firing lever 51. Automatic safety catch spring 52. Milled head with oil brush 53. Bottom plates 54. Hole for elevating joint pin 55. Outside plates breech casing 56. Filling-in piece. 57. Crank roller 58. Roller 59. Check lever 60. Knob on crank handle 61. Crosshead lug 62 Fusee spring box 63. Fusee spring 64. Fusee links 65. Feed block 66. Bottom pawl axis pin 67. Bottom pawls 68. Top pawls 69. Feed block slide 70. Feed block lever 71. Bracket retaining feed block lever 72. Spring retaining feed block lever bracket 73. Top pawl axis 74. Top pawl spring 75. Hexagon of crank shaft 76. Fusee spring adjusting screw 77. Fusee 78. Crank bearing 79. Slot in outside plates in which crank bearings move 80. Stop screw for firing lever 81. Firing lever axis pin 82. Rear crosspiece fixing pin 83. Automatic safety catch 84. Guides in which flanges in lock move 85. Crank stop 86. Projection on trigger bar 87. Extractor firing pin hole 88. Steam tube socket (rear) 89. Holes in steam tube 90. Screw fixing steam tube 91. Emptying plug 92. Filling plug 93. Muzzle attachment 94. Muzzle attachment plug 95. Steam tube 96. Slide valve 97. Water jacket 98. Steam tube socket (front) 99. Steam escape hole 100. End cap 101. Gas escape holes in muzzle attachment 102. Muzzle asbestos packing 103. Foresight fixing screw 104. Foresight 105. Cork plug 106. Feed block spring guide for cartridge cannelure 107. Cartridge stop

It is to be noted that when firing automatically a complete cycle occurs in the space of $\frac{1}{10}$th of one second.

Barrel. This is of very high grade "Vickers" steel drawn down under a Ryder hammer from a round bar. While at the muzzle end it is about the same thickness as a rifle barrel, it is much larger at the breech end. At this end it has a reduced part reinforced by a block with barrel trunnions on each

end. This is screwed on to the barrel, and has in it a stud on each side called the *trunnion bearing* to attach it to the recoil plates, and is recessed for a cartridge head and extractor. The barrel is bored and finished, rifled and chambered in a similar manner to the ordinary rifle barrel; but it is also hardened internally for some distance from the breech to withstand the high temperature of continuous firing. This is done by heating this portion of the barrel, after it is rifled, in a muffle, and then by attaching an oil and water injection pipe, through which first oil is forced and then water. This gives it a harder surface well in front of the chamber that to some extent prevents the lands and grooves being washed away or eroded by the flame of the nitro-cellulose powder. It is then finished, chambered, and touched up, bobbed out to correct any little irregularities due to the hardening process, and finished turned, and also has a deposited copper coating on its outer surface; the breech block is then screwed on dead home in such a way that the axes of the trunnions are at right angles to the axis of the barrel.

Casing. This consists of two plates with two hardened cam plates riveted on, a bottom plate, a rear crosspiece, and a hinged top cover. The side plates are of saw plate quality, and are first flattened out, and then edge planed, drilled to template, and two hardened cam plates are riveted on inside. These control the path of the carrier. In each side plate is a gap extending to the rear edge, for the crank bearing of the recoil plates to slide in. The rear portion is milled to a V shape, and filling-in pieces are fitted in, to close this portion. They can be removed when the rear block is taken off, so that the barrel and all the action can be withdrawn. The bottom plate is of bronze. It is drilled, and the side plates are riveted to its angle fillets. There are also gaps machined through for the feed box, and pin holes for the spring box on the left-hand plate.



23. FEED BOX AND BELT, MAXIM R.C. GUN

Cover. The steel cover has a gunmetal casting with cam projections downward on it to ensure the extractor dropping on recoil of the lock. They also keep the lock down when back. This casting (which also contains a recess for the backsight spring) is machined first and riveted in the correct position; a spring catch is fitted on the rear end of the cover. Holes are drilled for the tangent sight in the upper face, and a milled-out hinge piece is riveted on the front end. The rear crosspiece is a gunmetal casting with a bottom hinge to the side plates; also a pin to secure these passes through them. This pin has a turned T-head split pin to make it readily removable. The rear crosspiece is milled out to take the firing lever, and drilled for its pivot pin. A gunmetal safety catch with its springs is attached. The gunmetal castings on arrival from the foundry are well cleaned and pickled in acid solution and then machined in fixtures to templates and gauges.

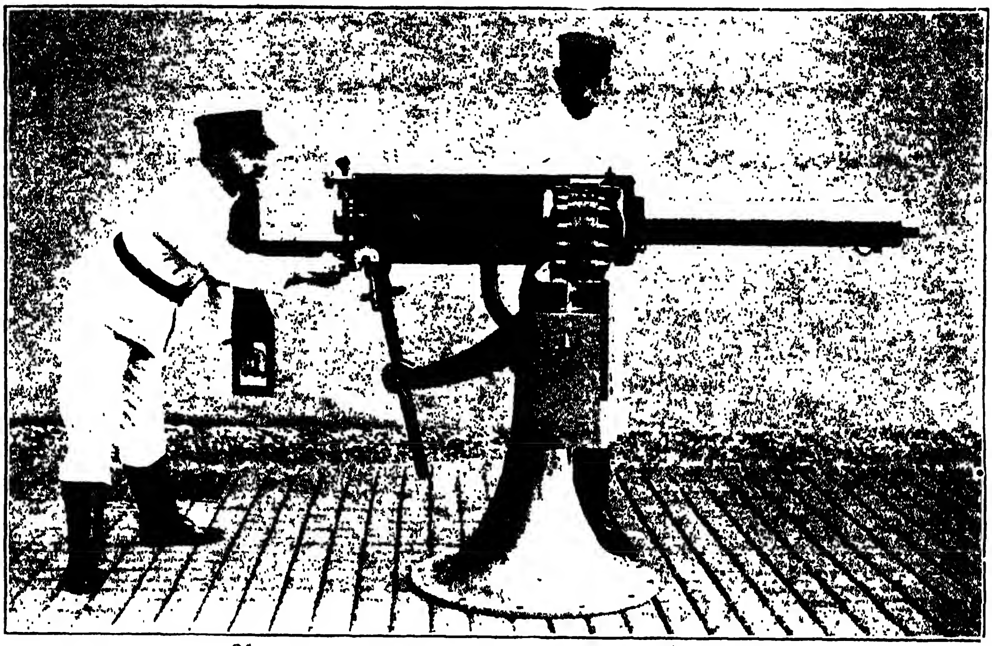
The Water Jacket. The water jacket is made up of a rear block and tube and front cap. The tube is either a bronze casting, or, as in the latest type of steel, with corrugated gills.

The rear block for the water jacket is a bronze casting joining by screw threads to the water jacket in front, and extending rearwards to form a sleeve for the barrel with an ejector tube below it; its top portion has hinged cheeks for the lid. At the side are two dovetails to form a rigid connection with the casing. This casting requires very careful coring and moulding to prevent contraction flaws. After casting it is pickled and sent to the machine shop. The sides are planed or milled parallel, and the fore end turned and screwed. The front and rear faces are milled to length, and the male screw thread is cut on its fore end. The holes for the asbestos-packed barrel breech are bored out and carefully finished to give a good sliding fit to the barrel. The top face is milled across, the hinge cheeks milled through, and the pin holes drilled. The dovetails must be very carefully machined and fitted on to the casing, being driven home with a raw hide or lead hammer. It is drilled for the axis pin and recessed for the extractor spring.

The Tube. When this is of bronze it is a cylinder cored hollow; it must not be porous. It is turned up and polished outside, screwed at both ends, and the sight bed is machined. A water plug and drain plug are screwed in. When in position it must be adjusted so that the sight is vertical.

Front Cap. This is a bronze casting with front gland, with asbestos packing to make hydraulic slide joint. There are screwed plugs to receive the steam tube end. When assembled, a boring bar is passed through this gland and the bearing in the rear block to ensure correct alignment, or this would grip the barrel and prevent it sliding properly.

Lock Frame. This [20] is of steel, broken down from the bar, and is a beautiful stamping with the vertical horn web and slides, also side trunnion projections raised up. It is first faced on the front face and slides and wibbled out on the sides, and the two solid side trunnions are formed by hollow mills through a fixing. Then the interior is milled out between the side cheeks in a jig, using the two first machined surfaces as spotting points; then a guide race for the firing pin is slotted out longitudinally, the striker hole is coned out, and the top stop machined. After the outside of the side walls are machined, the pin holes are drilled and reamered out through a jig, so that they are true to pitch and square with the rest of the lock frame when the lock frame is completed outside. The side levers are previously machined, are slipped over the side bearings, and joined together at the rear by riveting them on a square block. The block has a projection rearward forming the male portion of the bayonet joint, and the extractor lever stampings are machined and mounted. The various components, firing pin, and tumbler are machined and hardened. The front face of the thrust block, on which the base of the cartridge rests, is tempered very hard. In front of the lock frames, and gripping it with flanges, is the extractor. The extractor contains a gib with its spring and back plate, and the tail spring. The centre portion is a solid block, through which the point of the striker pass s. The front face also has small flanges vertically, but these are discontinued below to liberate the empty cartridge case when in the up position. This component is carefully recessed out by former mills for the gib; also the cone for the firing pin is bored out, and the grooves to form the guides milled. The tail spring is riveted at its lower end to the extractor.



24. 37-mm. MAXIM AUTOMATIC SHELL GUN (POM-POM)

Recoil Plates. These are flat steel plate stampings with square crank bearings stamped up; the left-hand plate has a forward prolongation with an open slot, which engages the bell crank lever, and gives transverse motion to the cross slide of the feed box. It is squared first on the top and bottom edges, and then the outside faces are milled across, leaving the crank bearings projecting up. The insides have projections inwards left on them to form stops to the upward movement of the crank cheeks; also grooved guides are milled in them to contain the extractor slides on the front end. The crank axis holes are drilled and bored out dead square with the plates in jigs, and the front fork or slot of the left-hand plate is machined out with a slight radius. The slides and fore end and axis holes are all oil hardened, after heating in a muffle furnace.

Crank and Connecting Rod. The crank is a solid stamping with two web cheeks and axles projecting on each side of them, hexagonal at one end for the hand lever, and at the other for the fusee. They are first turned on the axle parts. The cranks are milled out between the webs, leaving a wedge-shaped portion there; also, outside, they are machined by gang mills. The crank pin hole is bored through the cheeks in a jig and slightly countersunk, and then the finished pin is riveted in place.

25. LEWIS AEROPLANE GUN ON A TRIPOD

Feed Block. The feed blocks [21 and 22] are bronze castings, and contain the steel pawls, slide, and lever. The casting is machined longitudinally outside to fit the casing plates, and transversely inside to suit the various shaped cartridges, also for the cross slides, and bored for the lever. The bottom steel pawl has a fixed fulcrum in the casting; the top pawl is on the slide. The longitudinal movement of the recoil plates imparts a transverse movement to the slide through the bell crank lever, and the top pawl slides back over the cartridge and feeds it forward on the return stroke, the bottom pawl retaining the cartridge belt [23] in position.

Hotchkiss Machine Gun. The only other type of automatic machine gun that has been adopted is the Hotchkiss, which is used by the French and other Governments. It is simple and effective. It has no water jacket, but a very thick radiator barrel, and the number of working parts is small. It can be stripped and reassembled by hand if necessary without the use of tools. It was in use in the Boer War. Another type of Maxim gun, or Pom-pom, is shown by the 37-mm. shell gun [24] somewhat on the same principle as the R.C. type described. This gun fires small shell of about 1½ in. diameter. The Lewis aeroplane gun is shown in 25 and on page 2509.

JOHN W. WAINWRIGHT

Profit and Loss Account by Single Entry. Hire Purchase Accounts. Interest. Mining Royalties. Chartered and Incorporated Accountants.

SINGLE ENTRY & ROYALTIES

LITTLE has been said hitherto upon the subject of keeping books by what is known as single entry. The reason has been that no accountant would recommend the keeping of books by these means in a business of any size. Having regard to the fact, however, that there are many small traders who do keep their books in this way, it is necessary that some description of the process should be given. The great drawback of the method is the impossibility of proving the accuracy of the records kept under it.

Single Entry Methods. The books in use vary in different businesses, but usually there are a cash book and a ledger; sometimes there is a day book. What semblance of a system there is in keeping books by this method consists in entering in the cash book all cash received, from whatever source, and all cash paid away, for whatever purpose, and in keeping accounts in the ledger for customers owing money to the business. Sometimes the ledger contains also the accounts of wholesale dealers from whom goods have been purchased on credit. The "system" is usually a mixture of double entry and single so far as the practice observed in keeping the books is concerned. No goods account is kept, and the only way in which purchases and sales are recorded is on the cash and personal accounts. When a cash sale is made the cash received is merely entered on the debit side of the cash book, but no posting is made to the ledger. This is mere single entry, there being a debit entry, but no corresponding credit.

Ledger Entries. In a sale on credit the customer's account in the ledger is debited, but there is no credit to a goods or sales account. This is single entry. But when cash is received from a debtor in respect of goods previously sold on credit with which he has been debited, the amount received is not only entered on the debit side of the cash book, it is posted to the credit of the customer's account. This is complete double entry. Similarly, when payments are made for cash purchases the payments are recorded on the credit side of the cash book, but are not posted to a ledger account. Further, cash paid for rent, wages, and other expenses of the business, although entered on the credit side of the cash book, are not posted to nominal accounts in the ledger. Where no ledger accounts are kept for creditors the same principle is applied, and payments made to persons who have supplied goods on credit are not posted to the ledger. But where ledger accounts have been opened for persons who have supplied goods on credit the payments to them are posted to their debit, as well as being entered on the credit side of the cash book. This, of course, is again complete double entry. There is thus very little system about single-entry bookkeeping, and this failing is particularly felt when a trader desires to know the result of his operations at the end of a year's transactions. To meet his wishes in this respect a means has to be devised for arriving at the desired result with some degree of accuracy; but although errors of magnitude can be avoided by the exercise of common-sense, it is not possible to place absolute reliance upon the result obtained.

Single Entry Profit and Loss. The first step to be taken is to dissect the cash book. Taking the debit side, the receipts will probably be found to consist entirely of cash sales and receipts from debtors on credit sales. There may be also some items in respect of further capital introduced by the proprietor. The credit side will consist of payments for cash purchases, to persons for credit purchases, rent, wages, rates, carriage and miscellaneous trade expenses. There will be also the proprietor's drawings, and these must be carefully inquired into, for money is frequently withdrawn from a business by the proprietor without a record of the fact. The ledger accounts must then be analysed to ascertain the amount of the credit sales, which will consist of the posting of goods to the debit of the personal accounts. These can be approximately checked by comparing the total of the entries with the cash received from debtors during the year plus the debts outstanding. After providing for any discounts or other allowances made to debtors, the two totals should agree. The same course must be pursued with the credit purchases, and a similar comparison made.

The value of the stocks at the beginning and end of the period will be required, and if these are obtainable a trading and profit and loss account can be prepared. There is, as a rule, no difficulty in obtaining the stock at the close, but that at the beginning is not usually so readily procurable unless it is a new business. The initial stock is generally the most uncertain element in the accounts prepared on this plan, and if it was not taken in a proper manner at the beginning of the trading period it must be estimated.

Inasmuch as the whole result will depend upon the estimate formed, it must be very carefully made, and the usual means adopted is to take the closing stock at cost, add to this the total sales, less a percentage for gross profit, and then deduct the purchases. Here,

of course, everything depends upon the trustworthiness of the percentage of gross profit, and if any other means are available the result should be tested by them. Care must be taken to ascertain if there are any outstanding liabilities not recorded in the books, in respect of rent, rates, wages, or other expenses, as these may materially affect the result. Having taken the above steps, a profit and loss account and balance-sheet can be prepared in the usual form.

Conversion to Double Entry. The trader, after the trouble he will have experienced in obtaining these results, will probably desire to revise his methods of keeping his accounts in the future. If so, the first steps to be taken will be to bring into use purchases and sales books for the recording of all goods bought and sold on credit. The periodical posting of these books and the cash book into the ledger, together with the opening of a goods account and the various nominal accounts, will make his books capable of proof, and the results of accounts showing his trading operations thoroughly reliable.

If he decide to keep his books on double-entry principles in future, all that need be done to record in his books the position shown in the balance-sheet is to open ledger accounts for his stock, for his capital, and for the creditors if there are not accounts for them already. This having been done and the purchases and sales books brought into operation, the record of his transactions will proceed upon ordinary double-entry lines.

Hire - purchase Accounts. Many businesses are now conducted upon the instalment plan—*i.e.*, they sell their goods upon the terms that they may be paid for by the purchasers gradually by periodical payments. When this is the case, the price at which the goods are sold is naturally higher than that at which they would have been sold for cash. This increased price is due to the fact that the seller does not receive the purchase price at once, but only a small portion of it, and he, therefore, charges interest on the part unpaid. It is this factor of interest that occasions the necessity of keeping the accounts of such businesses—known as *hire-purchase accounts*—on special lines.

Formal agreements are entered into when sales of this nature take place, and for the protection of the seller they generally treat the transaction as one for the hire of the goods, which are to be made over to the hirer at the end of a stated period (provided the instalments are regularly paid), either without further payment or upon payment of a trifling amount. But, although the agreements usually treat the transaction as one of hire, it would not be correct for the seller to treat the periodical payments he receives as income which he is entitled to take to credit in full in his profit and loss account and yet at the same time treat the goods as his property, although in the hands of another. He must deal with the matter on the basis of a sale. But he must not take credit for the full amount charged to the purchaser, since that price includes interest which is only accruing due over a more or less lengthened period.

Manufacturer's Books. Business is conducted on these lines in connection with railway waggons, house furniture, pianofortes, cycles, etc., all over the kingdom, and it was principally in relation to railway waggons that accounts were first specially designed to meet the facts of this particular class of transaction. To take the case of the manufacturer first, it will be necessary for him to have his sales book ruled with two money columns—one for principal, the other for interest. When a sale is made on the hire-purchase system the manufacturer knows how much of the total price is for interest, and he enters the amounts in the two columns accordingly. The total price will be debited to the customer, the sales account will be credited with the amount of the principal or cash price, and the interest account with the balance.

The sold ledger will be ruled with two columns on each side—one for principal, the other for interest. A note will be made at the head of each customer's account as to the manner in which the price is to be paid. The debit to the customer will be divided into principal and interest, and the two amounts entered in the appropriate columns. As he pays the instalments cash will be debited and he will be credited with the full amount, the proportion attributable to principal being entered in the principal column and that to interest in the other column. The earlier instalments will, of course, include a greater proportion of interest than the later, owing to there being a large amount of principal outstanding upon which interest has to be charged.

When the manufacturer is making up his accounts at the close of a trading period, he must not take credit for the full amount of interest which has, during the period, been credited to the interest account, as sales were effected. Although interest has been charged to the hirers or purchasers it has not all been earned, and a rebate, or allowance, must therefore be made in respect of interest charged on the various purchasers' accounts, but which has not yet accrued due.

He should also make provision for the fact that if some of the goods were returned by the purchasers they would probably not be worth the amount at which they stand to the debit of the various customers' accounts. In some businesses this might not be so after a few payments had been made, but the manufacturer must, after taking all the circumstances into consideration, make such allowance as is in his opinion sufficient under this head. In order that the student may follow the working of this system the specimen of a customer's account in a manufacturer's ledger is given on the next page.

Hirer's Books. The matter has now to be considered from the view of the hirer or purchaser. When the agreement is entered into he does not credit the manufacturer with the full amount of the purchase price, as the latter becomes a creditor only when the instalments fall due. The method adopted, therefore, is to

Agreement No. 1,853. | W. BROWN. | 36 Monthly Payments of £3.

Dr. | Cr.

		Interest.	Principal.			Interest.	Principal.
1906. Jan. 1	To Sales Account		90 0 0	1906. Jan. 1	By Cash . ..	0 15 0	2 5 0
	„ Interest „	18 0 0		Feb. 2	„ „	0 14 2	2 5 10
				Mar. 2	„ „	0 13 4	2 6 8
				April 3	„ „	0 12 5	2 7 7
				May 2	„ „	0 11 6	2 8 6
				June 1	„ „	0 10 7	2 9 5
				„ 30	„ Balance ..	14 3 0	75 17 0
		£18 0 0	90 0 0			£18 0 0	90 0 0
1906. July 1	To Balance.. ..	£14 3 0	75 17 0				

debit an account opened for the article purchased —waggons, furniture, or as the case may be, with each instalment as it becomes due, and credit the manufacturer. When the instalment is paid the manufacturer is debited and cash credited. The result is that, provided the instalments are paid promptly, there is no balance on the manufacturer's account, as the credit of the instalment is immediately extinguished by the debit of cash. As the price of the goods, as we have seen, includes a considerable sum for interest, care must be taken to ensure that the articles purchased are included in the annual balance-sheet at not more than their actual value. This value will be the portion of the price which has been paid in respect of the principal amount due, irrespective of interest.

The purchaser must ascertain how much of the price payable under the agreement is for interest. He can generally obtain the information from the manufacturer, or can arrive at it by finding out the cash price as compared with that which he is paying. The difference will, of course, be interest, of which, as already stated, the larger proportion will fall against the earlier years. At balancing time an adjustment must be made by debiting the interest apportionable to the year to the profit and loss account and crediting the account of the articles purchased, which will thus stand at their cash price in the books.

Depreciation. In addition, provision must be made for the depreciation of the articles, and the allowance calculated, not upon the portion of the price actually paid, but upon the full cash price. This depreciation is put through the books in the ordinary way by debiting depreciation account and crediting the asset account with the amount written off. The net result of these entries will be that the asset will stand in the books at the end of the period over which the payments have been spread at its actual value to its owner.

This method of dealing with articles bought on the hire-purchase system is obviously only necessary in the case of a trader who has made a purchase of considerable value by these means. The ordinary man who has bought a cycle or pianoforte by instalments does not keep an account at all, but it is of the utmost importance in the case of an hotel-keeper who has purchased a large quantity of furniture on the system, or a colliery proprietor who has bought a number of waggons. Unless both these individuals take steps to show the articles they have purchased at their cash value only they will be overstating their profits, because they will not be debiting the profit and loss account with the interest on what is in effect borrowed money for the purchase of the articles.

ROYALTIES

A *royalty* is an amount paid by a person for the right to use the property of another. Thus the lessee of a mine pays a royalty to the owners of the land on which the mine is situated; a theatrical manager pays a royalty to a dramatic author for the right to produce his play; a manufacturer to a patentee for the right to use his patent, and so on. The amount paid in respect of the royalty depends upon the extent of the use which is enjoyed by the lessee or concessionaire in each case. A rate is usually fixed per unit. In the case of a colliery it is either upon the tonnage output or the superficial or cubic area worked. In the case of a patent it will depend upon the number of articles produced, in the manufacture of which the patent has been used; and in the case of a play it depends upon the number of performances.

It will be seen, therefore, that the amount paid in respect of a royalty is as much an expense of the particular business paying it as the rent, salaries, and other working expenses. It must be treated in the same way as the other expenses and debited to the profit and loss account. As the amount depends upon the extent of the user, a careful record must be kept, which must be available for inspection by the owner of the property, showing the output or production as the case may be. The form which the record will take must depend upon the nature of the property for the use of which the royalty is paid. In the case of a colliery, if the royalty is upon tonnage, the amount recorded in the pit books and agreed by the workmen's check weigher will be accepted by the landlord; while if it is upon areas it will be fixed by survey. In most cases, when once the amount payable has been agreed, the entries to be made in the books of the business having the use of the property are simply a debit to the profit and loss account under the head of royalties, and a credit to the owner. When he is paid he is debited and cash credited, and this will close the matter until the next periodical payment becomes due.

Mining Royalties. But in the case of a colliery a slight complication frequently arises. The form which the concession usually takes is

a lease of the land for the purpose of working the mining rights subject to the payment of a minimum annual sum. An amount of royalty is also fixed, which we will assume is payable upon the amount of coal raised. The fixed minimum is usually known as *dead rent.* If it exceeds the royalty upon the coal raised in a particular year, then nothing beyond the dead rent is payable; but if, on the contrary, the royalty exceeds the dead rent, the latter becomes merged in the royalty and only the royalty on the tonnage is therefore paid.

Redeemable Dead Rents. There is often a further provision in the lease that payments of dead rents in excess of royalties may be recovered by deduction from future royalties when these exceed the dead rent in a particular year. But the operation of this right is usually limited as to the time within which it may be exercised. The time limit is frequently five years. Thus, unless by the end of the fifth year the royalties exceed the dead rents, any excess dead rent on the first year will become irrecoverable, while if that state of things continued for another year, the excess on the second year would be lost to the lessee. So long as the right of recovery exists, the excess of dead rent paid is carried forward as an asset, the only charge to the profit and loss account in respect of the sum payable under the lease being the royalty on the coal actually raised. But so soon as the period has gone by within which it could have been deducted from excess royalties, it must be written off to profit and loss.

The working of the following example will show the student how the redeemable dead rent and the royalty accounts are dealt with in the books of the person working the colliery: A lease of a colliery is granted at a minimum dead rent of £600 per annum, merging into a royalty of 1s. per ton, with a right to recover dead rents out of royalties paid within five years. The quantity of coal raised was 800 tons the first year, 4,600 tons the second year, and 75,000 tons the third year.

It will be observed that the amount received by the landlord for the three years—*viz.*, £4,020—is the amount of the royalty on actual output.

Investigation and Audit. Our method in dealing with the subject has necessarily been to describe the process of recording transactions of different kinds in the books of an undertaking. The organisation of accounts on such a basis as to facilitate the keeping of the financial records of the business, and to give the proprietor of the concern the information he requires in the best possible way, is an important branch of the accountant's profession, but one not less so is that dealing with the investigation of accounts, including their audit. The business man is well advised who leaves investigation and audit to a skilled accountant, for no man who has not been specially trained to the work can be regarded as a reliable investigator and auditor of accounts. There are two societies of professional accountants in England and Wales—the Institute of Chartered Accountants, which confines its operations to these countries, and the Society of Incorporated Accountants and Auditors, which has branches in other parts of the world. The members of the former body

Dr. REDEEMABLE DEAD RENT ACCOUNT *Cr.*

1903. Dec. 31	To Landlord	600 0 0	1903. Dec. 31	By Royalty on 800 tons	40 0 0
				,, Balance c/d. ..	560 0 0
		600 0 0			600 0 0
1904. Jan. 1	To Balance b/d. ..	560 0 0	1904. Dec. 31	By Royalty on 4,600 tons	230 0 0
Dec. 31	,, Landlord	600 0 0		,, Balance c/d. ..	930 0 0
		1,160 0 0			1,160 0 0
1905. Jan. 1	To Balance b/d. ..	£930 0 0	1905. Dec. 31	By Landlord	£930 0 0

ROYALTY ACCOUNT

1903. Dec. 31	To Dead Rent A/c. ..	40 0 0	1903. Dec. 31	By Profit and Loss A/c.	40 0 0
1904. Dec. 31	,, Dead Rent A/c. ..	230 0 0	1904. Dec. 31	,, Profit and Loss A/c.	230 0 0
1905. Dec. 31	,, Landlord	£3,750 0 0	1905. Dec. 31	,, Profit and Loss A/c.	£3,750 0 0

LANDLORD

1903. Dec. 31	To Cash	600 0 0	1903. Dec. 31	By Dead Rent ..	600 0 0
1904. Dec. 31	,, Cash	600 0 0	1904. Dec. 31	Dead Rent	600 0 0
1905. Dec. 31	,, Dead Rent Recoverable	930 0 0	1905. Dec. 31	Royalty on 75,000 tons	3,750 0 0
	,, Cash	2,820 0 0			
		£3,750 0 0			£3,750 0 0

are known as chartered accountants, those of the latter as incorporated accountants. The chartered institute dates from 1880, the incorporated society from 1885, and both have large memberships. It will be seen from the dates mentioned that, as compared with medicine and the law, the organisation of the profession of accountancy is comparatively young; but it should be mentioned that societies of earlier foundation were merged in the institute on its formation, and, of course, the practice of accounting in a more or less primitive state dates back to the early ages. There are accountants' societies in Scotland and Ireland, the former being much older than the English bodies.

Professional Accountants. The conditions for admission to membership of the various societies are practically the same, the principal rule being that intending members must serve at least three years' articles of apprenticeship to a practising member. During the period under articles the would-be accountant is learning his business in its various aspects, a considerable portion of his time in the earlier years being occupied in acting as junior clerk on audits. In the later years he is, naturally, doing more important work, and gradually acquiring a knowledge of the different branches of his profession. He is required to pass a preliminary examination before admission to articles, and during his service he has to pass an intermediate examination. At the expiration of his articles he presents himself for his final examination, and if he satisfies the examiners is admitted to full membership of his society. The subjects of examination are, of course, those of which a knowledge is required by the accountant in his profession. They are set out in full on pages 136 and 981.

The proper training and examination of a body of men capable of investigating the financial books of a concern, with a view to ascertaining the accuracy or otherwise of the records in them, is a work of immense value to the commercial community generally, having regard to the dependence which must of necessity be placed upon such records.

Merchants and others are not slow to avail themselves of the opportunity afforded them of checking the work of their employees by means of the audit of their accounts conducted by a professional accountant.

The class of work upon which incorporated and chartered accountants are largely employed is the audit of the accounts of private concerns and limited companies. The reason of the non-discovery of many of the frauds which have been exposed of recent years, particularly in connection with the accounts of Friendly Societies, has been the failure to employ professional men as auditors. Reliance has, instead, been placed upon the well-meant but quite incompetent examination of the accounts conducted by men who, in some cases, were quite ignorant of the first principles of bookkeeping. This condition of things still exists to a large extent, although matters are improving.

From what has been said, it will be apparent that, although certain principles and rules might be laid down in connection with the investigation of accounts for the guidance of the ordinary business man who wishes to know that his bookkeeping arrangements are satisfactory, or for the young clerk who desires to be more than a recording machine, it is not possible to give in the shape of an article the knowledge that is required to make the practical auditor and complete accountant. Something can be done in that direction, but the only satisfactory course for the beginner is to enter the office of a chartered or incorporated accountant, and go through the whole routine necessary fully to qualify himself; while for the business man engaged in his own affairs all the year round the only safe course is to employ a properly qualified accountant to audit his books periodically.

Work of a Professional Accountant. Professional accountants, in addition to their work as auditors, are largely engaged in examining into and reporting upon the accounts of businesses which it is proposed to convert into limited companies. This function, to which reference was made in the chapter on company work, is of the utmost importance, as the public probably place more reliance upon the certificate of the accountant as to the past working of the concern than upon any other statement contained in a prospectus.

Accountants are also extensively employed as trustees in bankruptcies and under deeds of arrangement, as liquidators in the winding up of companies, and as receivers of properties on behalf of mortgagees and debenture holders. In any of these capacities they may be required to carry on a business for a more or less extended period, or their duties may be confined to the realisation of the property to the best advantage, and the distribution of the proceeds among the persons entitled.

From this brief summary of some of the more important duties of the professional accountant the reader will see that a training in the office of an incorporated or a chartered accountant with a varied practice affords exceptional opportunities of becoming familiar with the working of all kinds of businesses. This fact is of considerable value, for many young accountants, after serving their articles, seek positions as secretaries, managers, and accountants of important companies and public bodies, and their prospects of success are greatly enhanced if they hold the diploma of one of the recognised societies.

J. F. G. PRICE

CLERKSHIP CONCLUDED

A Course in Typewriting begins in the next chapter in this Group

Division of a Compound Expression by a Monomial. Division by a Compound Expression. Examples.

ALGEBRAIC DIVISION

DIVISION OF A COMPOUND EXPRESSION BY A MONOMIAL

40. From the result of Art. **26** it follows, since division is the inverse of multiplication, that *to divide a compound expression by a monomial we take the sum of the quotients formed by dividing the separate terms of the compound expression by the monomial.*

Example **1.** Divide $6x^4-2x^3+4x^2$ by $-2x$.

Here, we divide (i.) $6x^4$ by $-2x$, (ii.) $-2x^3$ by $-2x$, and (iii.) $+4x^2$ by $-2x$.

Hence, the required result is

$$-3x^3+x^2-2x \quad \textit{Ans.}$$

Example **2.** Divide $15x^4y^5-12x^3y^6+3x^2y^3$ by $3x^2y$.

The quotient $=5x^2y^4-4xy^5+y^2$ *Ans.*

DIVISION BY A COMPOUND EXPRESSION

41. The method will be best understood by considering an example. Suppose we have to divide

$$10x-5x^2-8+x^3 \text{ by } x-2.$$

We must first arrange both dividend and divisor either according to descending or according to ascending powers of some letter contained in each. In our present example the only letter is x.

On thus rearranging the terms we obtain $x^3-5x^2+10x-8$ to be divided by $x-2$.

$$\begin{array}{rl} x-2)\,x^3-5x^2+10x-8\,(x^2-3x+4 & \textit{Ans.} \\ x^3-2x^2 \qquad\qquad & \\ -3x^2+10x-8 & \\ -3x^2+6x \qquad & \\ 4x-8 & \\ 4x-8 & \end{array}$$

Now, it is clear that the term of the highest degree, x^3, of the dividend must be the product of the terms of the highest degree in the quotient and the divisor. Therefore, the term of highest degree of the quotient is found by dividing x^3 of the dividend by x of the divisor; that is, the first term of the quotient is x^2. Now multiply the *whole* divisor, $x-2$, by this x^2, and subtract the product from the dividend. This gives us $-3x^2+10x-8$ for the remainder.

Evidently this remainder must be equal to the product of the divisor and the terms of the quotient, which have still to be found. Hence, in the same way as before, we see that the second term of the quotient is found by dividing $-3x^2$ of this remainder by x of the divisor; that is, the second term of the quotient is $-3x$. Multiply the whole divisor, $x-2$, by this $-3x$, and subtract the product from $-3x^2+10x-8$. This gives $4x-8$ for our second remainder. Then, exactly as before, we see that the third term of the quotient is obtained by dividing $4x$ of the second remainder by x of the divisor; that is, the third term of the quotient is 4. Multiply the whole divisor, $x-2$, by 4, and subtract from $4x-8$. There is now no remainder.

We have thus subtracted x^2 times the divisor, $-3x$ times the divisor, and 4 times the divisor; that is, in all, we have subtracted x^2-3x+4 times the divisor and found that there is no remainder. It follows, therefore, that the dividend is equal to x^2-3x+4 times the divisor. Thus x^2-3x+4 is the required quotient.

42. We see, then, that the process is as follows:

1. Arrange the divisor and the dividend in ascending or in descending powers of some common letter.
2. Divide the first term of the dividend by the first term of the divisor, to obtain the first term of the quotient.
3. Multiply the *whole* divisor by the first term of the quotient and subtract the product from the dividend.
4. Treat the remainder as a new dividend, and repeat the process until the highest term of the remainder is of a lower degree than the highest term of the divisor.

We shall now work a few other examples.

Example **1.** Divide $4x^4-8x^3-19x^2+53x-30$ by x^2-3x+2.

$$\begin{array}{rl} x^2-3x+2)\,4x^4-8x^3-19x^2+53x-30\,(4x^2+4x & \\ 4x^4-12x^3+8x^2 \qquad\qquad\qquad & -15 \; \textit{Ans.} \\ 4x^3-27x^2+53x \qquad & \\ 4x^3-12x^2+8x \qquad & \\ -15x^2+45x-30 & \\ -15x^2+45x-30 & \end{array}$$

Notice that it is not necessary to "bring down" *every* term of the dividend after each subtraction. In the above example, for instance, the -30 is not required till we reach the second remainder.

Some examples require greater care in arranging the terms for each subtraction.

Example **2.** Divide $a^3+b^3+c^3-3abc$ by $a+b+c$.

Arrange the dividend in powers of a. Treat b as next in importance to a.

$$a+b+c)a^3-3abc+b^3+c^3(\underline{a^2-ab-ac+b^2-bc+c^2\ \textit{Ans.}}$$
$$\underline{a^3+a^2b+a^2c}$$
$$-a^2b-a^2c-3abc$$
$$\underline{-a^2b-ab^2-abc}$$
$$-a^2c+ab^2-2abc$$
$$\underline{-a^2c-abc-ac^2}$$
$$ab^2-abc+ac^2+b^3$$
$$\underline{ab^2+b^3+b^2c}$$
$$-abc+ac^2-b^2c$$
$$\underline{-abc-b^2c-bc^2}$$
$$ac^2+bc^2+c^3$$
$$\underline{ac^2+bc^2+c^3}$$

The above division shows us that
$a^3+b^3+c^3-3abc=(a+b+c)(a^2+b^2+c^2-bc-ca-ab)$.

This result is very important, and should be remembered.

Example 3. Divide $a^5+a^4b+a^3b^2-a^3+a^2+b^3$ by a^3-a+b.

$$a^3-a+b)a^5+a^4b+a^3b^2-a^3+a^2+b^3(a^2+ab+b^2$$
$$\underline{a^5-a^3+a^2b}$$
$$a^4b+a^3b^2+a^2-a^2b+b^3$$
$$\underline{a^4b-a^2b+ab^2}$$
$$a^3b^2+a^2-ab^2+b^3$$
$$\underline{a^3b^2-ab^2+b^3}$$
$$a^2.$$

Here the quotient is a^2+ab+b^2, and there is a remainder a^2.

EXAMPLES 6

Divide
1. $-33a^3b^2c$ by $3abc$.
2. $12xy^4z^3$ by $-2y^2z^2$.
3. $-105abc$ by $-5abc$.
4. $4x^7y^2z^8$ by $4x^5yz$.
5. $27x^5-36x^3+18x^2$ by $-9x$.
6. $4x^2yz+6xy^2z-8xyz^2$ by $2xyz$.
7. $\frac{3}{4}a^2-\frac{1}{2}ab+3ac$ by $-\frac{1}{4}a$.
8. x^2-3x-4 by $x-4$.
9. $6x^2-19x+10$ by $2x-5$.
10. $2a^2-a-4a^5+1-3a^3-a^4$ by $a+1+a^2$.
11. $1-x^8$ by $1-x^2$.
12. x^4-a^4 by $x+a$.
13. $a^3-b^3-c^3-3abc$ by $a-b-c$.
14. $x^2-y^2+xz-yz$ by $x+y+z$.
15. $(a-1)^3+b^3$ by $a+b-1$.

Answers to Algebra

Examples 5

1. $3x^4y-3x^3y^2+9x^2y^3$.
2. $-4x^4y+4xy^4-4xy$.
3. $-5a^3bcxy^2z+5a^2b^2cx^3yz-5a^2bc^2xyz^3+10ab^2c^2xy^2z^2-10abc^3x^2y^2z$.
4. x^3+y^3.
5. x^3-y^3.
6. $x^4-a^2x^2+2a^3x-a^4$.
7. $x^4-x^3-2x^2+5x-3$.
8. $x^5-a^2x^3+(2ab-c)x^2+(ac-b^2)x-bc$.
9. $x^6-x^5y-4x^4y^2+3x^3y^3+x^2y^4+2xy^5+2y^6$.
10. $a^3+b^3+c^3-3abc$.
11. $(1-x)(1+x)(1+x^2)$
$=(1-x^2)(1+x^2)$
$=1-x^4$.
12. $(x^2+y^2+xy)(x^2+y^2-xy)(x^4-x^2y^2+y^4)$
$=\{(x^2+y^2)^2-x^2y^2\}(x^4+y^4-x^2y^2)$
$=(x^4+y^4+x^2y^2)(x^4+y^4-x^2y^2)$
$=(x^4+y^4)^2-x^4y^4$
$=x^8+x^4y^4+y^8$.
13. $\{(b+\overline{c+a})(b+\overline{c-a})\}\{(a-\overline{b-c})(a+\overline{b-c})\}$
$=\{(b+c)^2-a^2\}\{a^2-(b-c)^2\}$. Art. 34.
$=(b^2+c^2+2bc-a^2)(a^2-b^2-c^2+2bc)$. Art. 32.
$=(2bc+\overline{b^2+c^2-a^2})(2bc-\overline{b^2+c^2-a^2})$. Art. 19.
$=4b^2c^2-(b^2+c^2-a^2)^2$. Art. 34.
$=2b^2c^2+2c^2a^2+2a^2b^2-a^4-b^4-c^4$. Art. 32.
14. $(x-y)^2+(y-z)^2+(z-x)^2$
$=x^2+y^2-2xy+y^2+z^2-2yz+z^2+x^2-2zx$
$=2(x^2+y^2+z^2-yz-zx-xy)$.
15. $(x+2)(x+3)(x+4)(x+5)$
Since $2+5=3+4$, we multiply together the first and fourth factors and then the second and third, thus obtaining $(x^2+7x+10)(x^2+7x+12)$
$=(x^2+7x)^2+22(x^2+7x)+120$
$=x^4+14x^3+49x^2+22x^2+154x+120$
$=x^4+14x^3+71x^2+154x+120$.
16. $x^2y^2p^2-x^2y^2q^2+p^2q^2x^2-p^2q^2y^2+p^2q^2y^2-p^2x^2y^2+q^2x^2y^2-p^2q^2x^2=0$.
17. $9x^2-81+2x^2-8x+8-4x^2-4x+80-6x^2+12x-6=x^2+1$.
18. $x^2+9y^2+16z^2-24yz+8zx-6xy$.
19. $9a^4-12a^3+34a^2-20a+25$.
20. $a^2+b^2+c^2+d^2+2ab-2ac-2ad-2bc-2bd+2cd$.
21. $(a+b)^2(a-b)^2=(a^2-b^2)^2=a^4-2a^2b^2+b^4$.
22. $27x^3-27x^2y+9xy^2-y^3$.
23. $1-12a+48a^2-64a^3$.
24. $(x+y+z)^3=x^3+3x^2(y+z)+3x(y+z)^2+(y+z)^3=x^3+3x^2y+3x^2z+3xy^2+6xyz+3xz^2+y^3+z^3+3y^2z+3yz^2$.
25. $(x-y-z)^3$ is obtained by changing the signs of y and z in the last example.

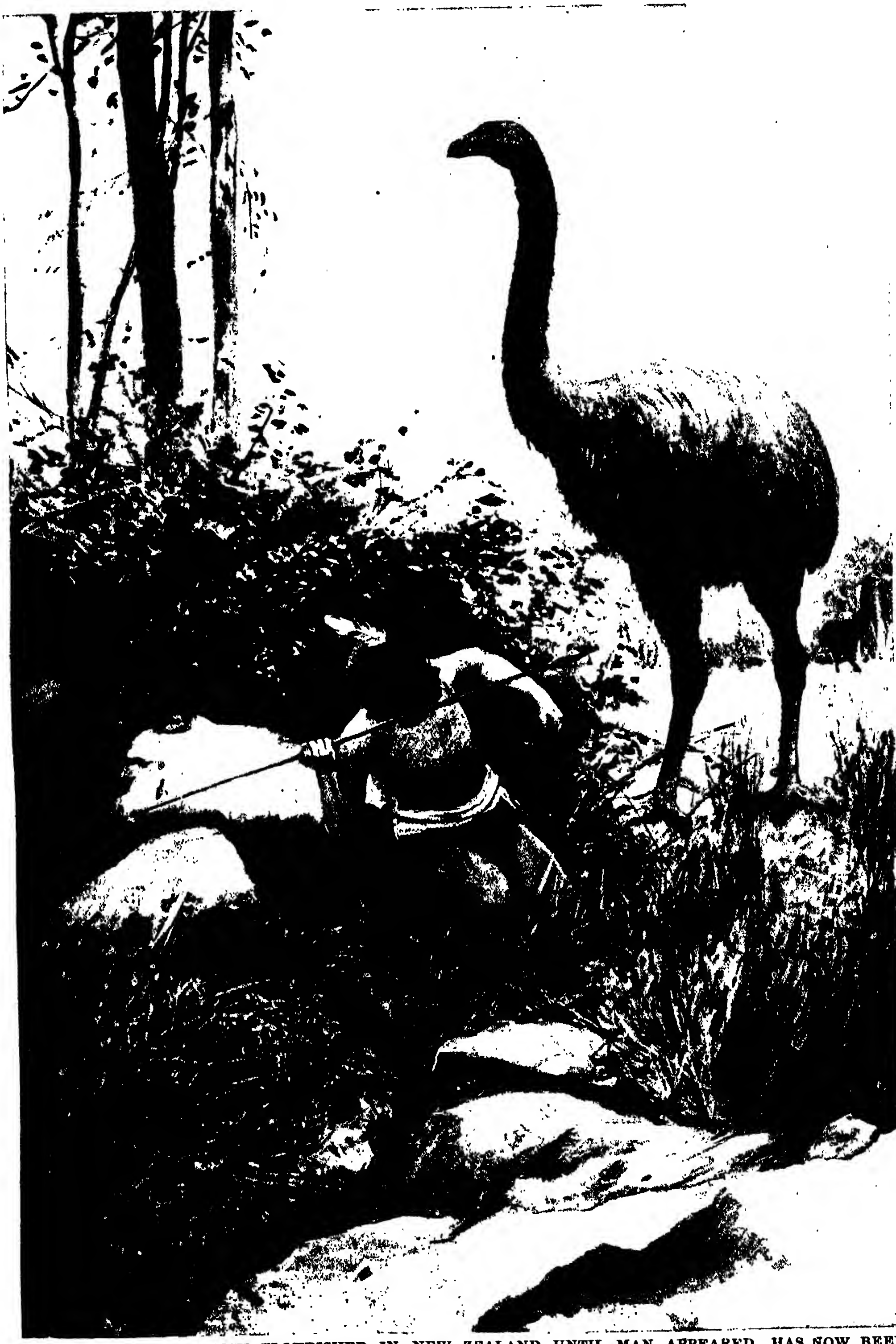
Thus,
$x^3-3x^2y-3x^2z+3xy^2+6xyz+3xz^2-y^3-z^3-3y^2z-3yz^2$.

Examples 6

1. $-11a^2b$.
2. $-6xy^2z$.
3. 21.
4. x^2yz^7.
5. $-3x^4+4x^2-2x$.
6. $2x+3y-4z$.
7. $-3a+2b-12c$.
8. $x+1$.
9. $3x-2$.
10. $1-2a+3a^2-4a^3$.
11. $1+x^2+x^4+x^6$.
12. $x^3-ax^2+a^2x-a^3$.
13. $a^2+b^2+c^2-bc+ca+ab$.
14. $x-y$.
15. $(a-1)^2-b(a-1)+b^2$.

H. J. ALLPORT

NEIGHBOURS IN THE WORLD'S EARLY DAYS



THE GIANT MOA, WHICH FLOURISHED IN NEW ZEALAND UNTIL MAN APPEARED, HAS NOW BEEN EXTINCT FOR PERHAPS 500 YEARS

How Social Intercourse rounds off Character. Leaping the Barriers of Caste. The Folly of Social "Bluffing."

THE VALUE OF SOCIAL LIFE

ONE of the ways whereby people who intend to make the best use of their lives will seek advancement is by winning through social intercourse the good opinion and interest of others who have attained some measure of success. Unless we are either dull, morose, or foolishly shy, we must see that social recommendations are a manifest advantage, and may be used in perfectly legitimate ways. Often, indeed, they are seriously needed.

The young man, for instance, who belongs exclusively to the working class, who only knows the working-class manner of life, speech, address, and average habit of thought, will suffer under considerable restrictions whenever he engages in open competition with men who have been reared in the midst of social surroundings that were less rough and ready. A heavy temporary handicap will hamper that young man's early efforts, and will continue until he has become acclimatised on a somewhat different social level. This, of course, is not always the case, for there are many working-class homes that compare in taste with the most cultured households, but it is true on an average. To dismiss the fact of pronounced social differences as mere snobbishness is to be blind to some thoroughly practical considerations, and to proclaim oneself a prejudiced observer of only one corner of the broad field of human life.

The man who is at ease in any grade of society where he may for the time being find himself has obviously a far wider range for his activities than he would have if he were self-labelled a member of a caste ; and it is therefore a sound instinct which leads men to seek the broadest social freedom. In these days of cheap and unlimited education one of the first tasks of the aspiring youth often is to "burst his birth's invidious bar," without degenerating into a snob. The attainment of social fitness—that is, the fitness which enables him to mingle in any company without being out of place—is a milestone on the pathway to success. In a preliminary way it opens the world to the new-comer.

What may be called social expansion asks for comment here the more insistently because it is beset with difficulties. While it is almost a necessity that the able man who would amply realise himself should become, at an early period, an easy but unassuming citizen of the world, one of the most repellent of modern spectacles, on the other hand, is the horde of money-makers and others vulgarly scrambling for social preference. Those who struggle for social standing for the sake of appearances and notoriety do not, as a rule, understand in the least the true values of a society to which good breeding essentially gives its tone.

The bustling climbers are not by any means confined to those who rely on a parade of real wealth. Other methods call equally for a warning. There are, for instance, many who by sheer bounce try to establish a useful position that may help them along the road to success. The mark of the adventurer is that he plans to appear what he is not, in the hope of stealing some social credit that may assist him towards becoming what he appears to be. There is, for example, the family that, for the sake of a temporary effect, pretends to be richer than it is It uses a large house as a means of advertisement, proclaims itself alive to the whims of fashion in clothes, and boldly tries to imitate the style of the people who undoubtedly enjoy social consideration. The supposition of the adventurer that he will impose on those who already are established citizens of the world is a poor compliment to their shrewdness, but it sometimes answers for a while, and then a disastrous fall occurs.

The fiction of riches is often accompanied by the fiction of superior family connections. The first step certain people take when they begin to follow the vision of a rise in the social scale that will enable them to use their new position as a fulcrum from which to achieve other successes is the cutting off of their family associations. Next, they throw out the suggestion that they were born to better

things than their present circumstances would appear to indicate. This attitude of the thorough-paced snob is an indirect proof of the high value the average person places on a good social position. In the hope of getting it he will precipitate himself into a state of existence that is naturally full of difficulties, for, as a matter of fact, the treatment of his family connections by a man who has become genuinely successful is often extremely perplexing. He may pass into a sphere where they, manifestly, would not be at ease, and could not remain in close attendance on him with any satisfaction. What is he to do ? At any rate the one thing he should not do is to conceal his origin under pretences. That is even worse than the ostentatious boasting by which some who rise disparage the family from whence they sprang.

Then there are the people who try desperately to appear better educated, or cleverer, than they really are, and who will allow quite false conceptions of their doings to be made current, in the hope that some degree of glorification may cling to them. The people, for example, who posture as literary without any warrant may be counted by the thousand. All pretentious claims, whether of wealth, birth, or brains, are bound to end, sooner or later, in the aspirant being discovered in a false position, and meriting and receiving contempt instead of honour. It is much the same with those who seek to secure a better position by paying court and rendering flattery to people who are so placed that they may be useful socially and otherwise. The average man has a very quick ear for the detection of the flattery which sounds the praise of others, however self-deceived he may be in his own case, and no one who becomes recognised as an adept in the art of self-seeking adulation ever gains widespread respect.

In the long run, it is only the man who preserves a clear sense of independence of mind and character, quiet self-respect, and the wish to be known for what he really is, who secures general acceptance in any grade of society. This is as true of the mass of the working class as of the circle that talks of culture and fashion. What a change would come over the tens of thousands who are trying to rise by show rather than by personality if they could be brought to see that only genuine desert can hold its own permanently; and that this truth rules finally in every sphere of human life—the world of business, the world of public affairs, the social world, the boundless provinces of mind and knowledge and literature ! And it is particularly true in the near, easy, and familiar region of social intercourse.

If this were understood, it would once for all undermine the position of all who, in pursuit of a false ideal of success, try to buy social consideration No canker eats so deeply into the body social as the substitution of money for personal worth. To see the untruthfulness of the temporary honour paid to money in modern life, we have but to note the opinion of the world on those who had much money but are dead. As no hope of gain affects opinion respecting those who were wealthy and are defunct, we see them regarded with unconcealed contempt, unless they had the qualities of manhood that naturally command lasting respect. If they were devoid of those qualities they remain under a sort of ban of resentment as illicit gatherers of contemporary credit. What rich man ever dared to challenge the scorn of mankind by putting on his tombstone what was perhaps the pride of his life: " I was rich " ? And yet myriads strive in life to insinuate themselves, by their wealth alone, into circles where they are secretly, and even openly, despised. Probably they have never thought out the real bases of success and respect, and are content with a mere show of temporary consideration. The most the moneyed parvenu can do is to purchase social toleration, and he is able to do it because society finds it convenient, for the moment, to accept the price he is willing to pay.

Turning from false social aims and methods, from the adventurer, the parasite, and the money-bag, let us see how an enlarged social experience may affect, legitimately, the man who is " finding himself " and making his way in the world by merit. Such experience has a value that may be easily overlooked by those who are devoted to some special form of work. Probably the provincial cities afford better illustrations than London of the use of social intercourse in rounding off character, and in making personality known in circles to which it would not otherwise penetrate. There, occasions arise frequently where all kinds of people meet socially at a variety of gatherings—balls, dinners, receptions, and the like—and the appearance, address, social adaptability,

and in some degree the general personality, of anyone who is invited may become known to many leading citizens. Practically everyone who makes any mark locally is brought, sooner or later, into this public circle, and proves to an experienced onlooker his fitness or unfitness for more private social intercourse on the level of good breeding. He may quietly create an impression that is a true forecast of his career, and, indeed, that may serve an introduction to it.

The successful student, the promising young business man engaged in any important enterprise, the eager publicist who would influence opinion, the energetic yet judicious official, the working-class leader, may here emerge into a wide social world—wider, possibly, than he has known—an extremely mixed world, no doubt, showing much that should be avoided, but also a virile world that may not only offer an education in social amenities, but afford a fine play of intellect, through a succession of conferences with minds of many types.

How should such opportunities be treated? They afford many men such chances of becoming known as cannot occur under equally favourable circumstances elsewhere. On the other hand, they are sometimes unused or misused. In the freedom of social intercourse an opinion is formed that certain men are broad, capable, tactful, and will go far in life, while others are seen to be limited in outlook, socially stunted, unfit for the finer forms of enterprise, blunderers, or marred by some kink in their nature which makes them "impossible" for certain purposes. Indeed, it is often under these social tests, which are also constantly applied in more private as well as public intercourse, that opportunities come to men, and offers are prepared for them by observers, which may amount to an altogether new lead in life.

To anyone, no matter what his upbringing has been, social intercourse that is generous in its breadth is valuable in enabling a man to "find" himself and, in some degree, train himself. That is the only true basis of success. The man seeks full expression of his mind and character. If he attains it, and succeeds in putting all of himself into some vital form, through work suited to his capacities, he can do no more, and he should be satisfied with no less. An extension of social activity and experience gives us adaptability, a power of managing men more easily, of laying ourselves alongside them for exchange of opinion, for business, for reception of what they can teach us. Without these attainments, how can we make the best of ourselves?

The prime secret of being able to take full advantage of all social opportunities that come in our way so that they may be truly educative is to cultivate first the captivating quality of sincerity—sincerity toned by considerateness. That is a frame of mind which is a universal commendation. Sincerity insists that we shall be our natural selves, without pretences; and considerateness insists that we shall not be aggressive, or impinge unduly on others, or be self-assertive, or showy, but shall be modest at all times, while sustaining our self-respect.

Whoever is possessed by that spirit has no need to trouble himself about public appreciation. His attitude will command an instinctive confidence. If he quietly holds his own on matters to which he has devoted careful thought, and is frank on points that are beyond his knowledge, if his nature is straight in the grain, and yet, while never being false to truthfulness, is sensitive towards even the prejudices of others, and so avoids the crudity of bickering or harsh contention, he will be honoured by all observers in their inmost hearts, as one who is temperate as well as firm. It is, on the one hand, the pushing men and swift aggressors, and, on the other hand, the flaccid men and the practised toadies, who are rejected instinctively.

Of course, the man who would take his place naturally in any society must be at the trouble to become acquainted with the best social usages, for there is always a sound reason for any conventional point of good manners. Some people profess to regard the ordinary rules of etiquette as if they were only forms devised by people inside good society as a bar against people who are outside. But such rules, disregarding, of course, the freak fashions which all sensible people avoid, have been well thought out, and are thoroughly practical in smoothing the path of social intercourse. If any rule does not wear well, it is soon discarded. A certain amount of experience in social intercourse is needed before anyone can be not only at ease, but graceful and helpful in general society; and every man owes it to himself

that he should undertake that practice both as a duty and an opportunity.

Many years ago, towards the close of his life, Matthew Arnold was speaking to a number of London teachers, and an outburst of almost impatient criticism followed his seriously spoken advice that each should " put on a suit of dress-clothes and go into society." That was quoted as an example of the great inspector's superior air. But what Matthew Arnold meant by that advice was perfectly sound. He saw that certain qualities which " go with " formal manners were missing from the average style of the teachers of that day, and he delicately hinted at a remedial method. There is no man in any grade of society, however simple its organisation, who would not be the better for such attention to the graces of social intercourse as Matthew Arnold had in mind when he used dress-clothes as a convenient symbol.

In all formal social relations personal bearing plays an important part. It affects some careers from earliest boyhood. Take the lad who is called up for an interview with the naval authorities after he has been nominated for training as a naval officer. At the age of twelve he may be rejected finally because he is awkward, unready, lacking in self-possession, and is adjudged as deficient in the qualities that develop into the gentleman. Possibly this test is premature, precarious, or wrong, but it points towards a general truth, operative in the world at large as well as in the Navy, that certain social endowments make smooth a man's path way through the world almost as certainly as his more positive virtues have that effect, and indeed allow his solid attainments and natural gifts to shine with a clearer light.

It may be objected that it is easy to make too much of social adaptability; that those who devote considerable attention to it are likely to miss their way in the world, and that the most forceful men the world has ever known have had little care for social graces. The truth of these limitations must be admitted. The acquisition of social polish is only an incidental part of a vigorous man's life, and should never be allowed to draw him away from his essential duties. Indeed, few types of men approach nearer to the contemptible than those who fritter away a considerable part of their lives on social amenities of the lighter kind. The world's great originals, too, the pioneers, the special workers, who push somewhat further the bounds of knowledge, absorbed in their work—generally of a lonely kind—view all social considerations as the very small dust of the balance. But these exceptions do not affect the general position, which is that the " full man " should be fitted for easy access to any society without a handicap from awkwardness or self-consciousness.

If the man with great and original abilities had been at ease in society, instead of lumbering, or dismayed, or " quaint," as some undoubtedly are, he would have lost not one whit of his special power, but would have reaped personal pleasure instead of discomfort when circumstances forced him into social intercourse. There is no conceivable virtue in uncouthness of any degree, but only distastefulness for all concerned. And if this is true of the genuine ability that can force its way against all surface disadvantages, how much more significant is it in the cases of men who have to do the best they can with their inherent powers without the imperious strength of genius! To them, at any rate, a reasonable attention to social demands and conventions is a valuable lubricant, smoothing the working of the wheels of progress, removing possible disabilities, and opening a way to chances which only the short-sighted or prejudiced will despise.

We have considered social intercourse as an adjunct to success, but that success cannot with fitness be predominantly personal and selfish. A man cannot inspire confidence and goodwill if he is revolving obviously on a pivot of self-interest. Social intercourse is a means of escape from such a narrow view, and affords opportunities of devotion to the common interests of mankind. It asks from a man a personal contribution to the common stock of social helpfulness. It widens his range of usefulness in ways never reached by the recluse. While society helps to broaden him, and reduce his angularities, he may help it with a quiet power that no one can resent, bringing to it, incidentally, wise and moderating thought, glimpses into the glorious resources of knowledge, a sense of all-embracing sympathy, even perhaps the moral fervour which raises the average man's conception of life, and certainly he may bring the benign power of a happy disposition.

JOHN DERRY

India: Its Physical Features, Climate, Vegetation, and Mineral Wealth. Basins of the Indus and Ganges. Ceylon, Assam, and Burma. Indo-China.

THE INDIAN EMPIRE

From whatever point of view we regard our Indian Empire, it presents great diversity. Its surface varies in elevation from the summit of the Himalayas to the sea level, and shows every type of fertility, from tropical jungle to arid desert. Out of nearly 1,800,000 sq. miles, with 315,000,000 people, about 700,000 sq. miles, with 71,000,000 people, are governed by native rulers, who stand in varying relations to the central power. There is no community of either race or religion, and all types of civilisation are represented, from the highly cultured Hindus to the semi-savage tribes of the jungle.

Physical Features of India. Enough has already been said of the great mountain ranges which wall in India on the north. Upon their flanks lie the mountain states—British Baluchistan, the North-West Frontier province, Kashmir, the wholly independent states of Nepal and Bhutan, and Assam.

At the base of this mountain wall extend the vast alluvial plains of the Indus and Ganges, built up in the slow course of ages out of the silt brought down by these mighty rivers and their tributaries. Five great tributaries of the Indus, the Jhelum, Chenab, Ravi, Beas, and Sutlej, water the Punjab, or Land of the Five Rivers, and unite to cross Sind to the Arabian Sea. The innumerable tributaries of the Ganges cross the United Provinces and Bengal, receiving in the deltaic portion the Brahmaputra flowing from Tibet and Assam.

The desert of Rajputana, under native rulers, lies between the Indus and the Ganges. The right bank tributaries of the Ganges flow in parallel valleys from the northern margin of the Deccan plateau, which occupies the centre of peninsular India. In the west it rises steeply from the sea. The high western margin, which, seen from below, appears as a mountain range, is called the Western Ghats, or Stairs. In the east it sinks gradually to a broad coastal plain, which extends along the whole length of the eastern, or Coromandel, coast. Here the much less well defined eastern margin forms the Eastern Ghats. The northern margin is well defined, and forms the Aravalli Mountains, south-east of which lie the Central Indian native states.

South of the Vindhya Mountains is the deep gorge of the Narbada, which flows west across the Deccan plateau and crosses the lowlands round the Gulf of Cambay to the Arabian Sea. Parallel to it, separated by the Satpura Highlands, is the Tapti. All the other rivers of the Deccan flow east, the Mahanadi, the Godavari, the Kistna or Krishna, Cauvery, and others. The plateau narrows with the peninsula, the southern margin forming the Nilghiri Hills. South of these is a remarkable depression, the Palghat Gap, beyond which rise the Anamalai Hills of the extreme south.

The most important political divisions of the Deccan are the Central Provinces and Berar, between the Narbada and the Godavari, the large native state of Haiderabad, between the Godavari and Kistna, while farther south is the native state of Mysore. Bombay forms the western and Madras the eastern maritime province.

Indian Climate. The climate of India, like its surface, is very varied. On the coasts the temperature is high throughout the year, with less variation than in the interior. The highest temperatures in summer are recorded in Sind, the Punjab, and Baluchistan. These regions lie more or less outside the influence of the rainy south-west monsoon, which lowers the summer temperature. Rajputana and Sind are almost rainless, forming an area of true desert.

Rainfall. The coming of the south-west monsoon, the most dramatic feature of Indian climate, has already been described. It strikes with great violence on the Western Ghats, which have a rainfall of over 100 in., while the Western Deccan in their lee has less than 20 in. The rainfall is also extremely heavy in Burma, Assam, and the Ganges Valley, the highest rainfall in the world being experienced at a place in the Khasi Hills, which has the enormous rainfall of 40 ft. per annum. Just before the monsoon bursts the Deccan is the hottest part of India, but during the monsoon months—June to October—the highest temperature occurs in Sind and the arid highlands to the west, where a shade temperature considerably above 100° F. may last for many consecutive days. The climate of all this region is very extreme, for the arid soil, unprotected by vegetation, loses its heat rapidly by radiation during the night, and the winters are cool. In the Punjab the hot summers are compensated for by several months of bracing, cool, winter weather.

In autumn the south-west monsoon begins to recede, its place being taken by the north-east trades, now moving south with the sun, and often called the north-east monsoon. It prevails from November to February. The first two months, called the period of the retreating south-west monsoon, is the wet season in South-east India and the eastern part of Ceylon, but the rainfall thus caused is much less than that brought by the full south-west monsoon.

Irrigation. The seasonal character of the Indian rainfall makes it a matter of prime importance to store water for use in the dry season. An ancient Indian method was

to construct tanks, subterranean reservoirs and artificial lakes. Innumerable wells were sunk to the water-bearing strata. Canals were also made to carry off the flood waters of the rivers in spring, when they are enormously swollen by the melting of the mountain snows. This surplus water was then distributed by smaller irrigation canals. Under British rule great engineering works have made not merely the flood but the perennial waters of the rivers available for irrigation. Wherever possible the country is covered with a network of canals, the regulation of which is one of the greatest services rendered by Britain to India. All these precautions, however, do not prevent local famines, whenever the south-west monsoon is scanty.

Vegetation. The vegetation of India is luxuriant or the reverse according to the rainfall. Everywhere it strikes unfamiliarly on the European eye. Palms are abundant, and are of many species. The coco-nut palm does best near the sea. Many of the tropical palms of Southern India and Ceylon cannot stand the cold winters of Northern India, but the hardy date palm thrives even in the dry, extreme climate of Sind. At the base of the Himalayas is the fetid jungle area known as the *terai*, deadly to Europeans. Above are magnificent forests of sal and deodar—a cypress—with tea plantations in the clearings. Above these are woods of brilliantly coloured rhododendrons, making a wonderful sight. The hotter, wetter forests of Burma supply teak, one of the hardest timbers in the world. It is also found in the Western Ghats and other hot, wet parts of the peninsula. Valuable forest trees are ebony, satinwood, sandalwood, the gum-arabic tree, and many others. The great banyan is grown as a shade tree. Of the many fruit trees unfamiliar to us, the pipal, or sacred fig, the mango, the tamarind, the guava, etc., may be mentioned. The bamboo, a gigantic grass, is very valuable, especially to the forest peoples, who can make from it almost anything that human needs require.

THE PRODUCTS OF INDIA

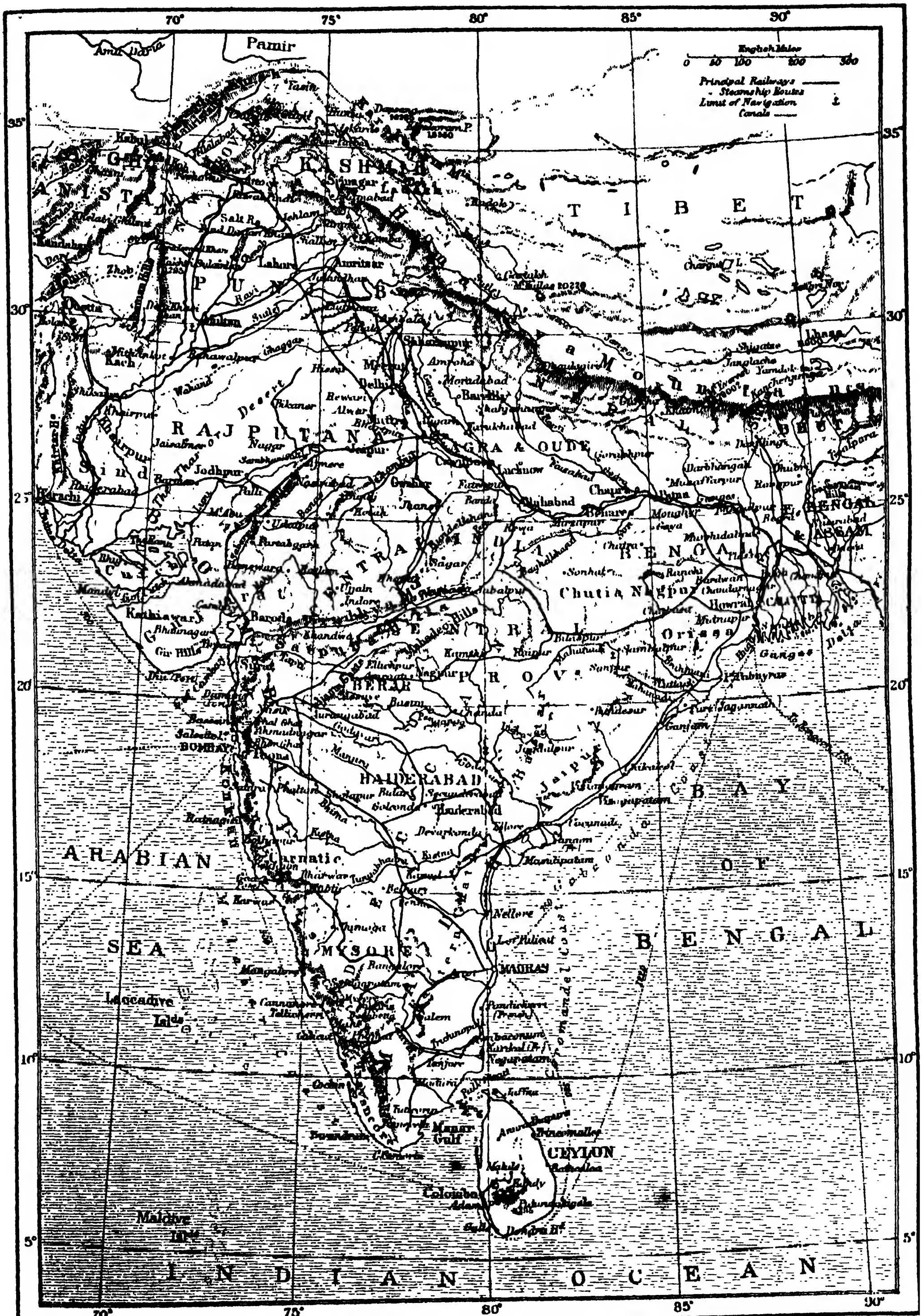
The cultivated plants include many cereals, the variety depending on the climate. Large quantities of wheat are grown in Northern India and in the Northern Deccan as a winter crop in the cool months. Rice, the typical cereal of warm, damp countries, is universally grown in the Ganges and Brahmaputra delta, in Burma, and in most of the swampy coastal plains of the peninsula. A universal crop is millet, which can be grown in poor soils. Other very common crops are pulses and oil seeds (sesame, linseed, rape, castor-oil, mustard). Sugar-cane, indigo, and tobacco are widely grown. Of fibre plants cotton and jute are important. The latter is confined to Bengal, but cotton is grown wherever there is a moderate rainfall. The great cotton-growing region is the Deccan, with its rich black, moisture-holding soil, and Gujerat. Tea in the Himalayas, and in the Assam hills, has already been mentioned. Coffee is cultivated on the lee slopes of the Western Ghats, in Southern India.

Minerals. The mineral wealth of India is considerable. Coal is worked in Bengal, Assam, Central India, Haiderabad, and Baluchistan. Southern India, though poor in coal, is rich in other minerals. Iron is widely distributed, but unfortunately seldom occurs near coal and limestone; gold is abundant in Mysore; tin, and petroleum are found in Burma; Upper Burma has fine rubies and Ceylon precious stones. Golconda, in Haiderabad, was proverbially famous for cutting and polishing diamonds, not for producing them.

The Occupations of India. India is primarily an agricultural country. A pastoral belt stretches across Northern India from Cutch to Kashmir, and everywhere flocks and herds are kept in the mountain pastures.

The manufactures of India—fine textiles and metal work—have always been famous in Europe. These, like the more common trades of the smith, potter, etc., are handed on from father to son, and skill and taste doubtless become hereditary. In recent years machinery and the factory system have been introduced, to the rapid deterioration of the manufactures affected. In Bengal jute factories make gunny-bags for packing exports. Cotton mills are numerous near the cotton growing regions in Bombay.

The Indus, Punjab, and Sind. The Indus and its great tributary the Sutlej rise between the inner and outer Himalayas in Tibet. Both first flow north-west, parallel to the axis of the mountains, but the Sutlej soon breaks south through the Himalayas in magnificent forested gorges, to the plains of the Punjab. The Indus flows in wild and gloomy defiles through the bleak scenery of Eastern



Pamir
English Miles
Principal Railways
Steamship Routes
Limit of Navigation
Canals
70°
75°
80°
85°
90°
35°
30°
25°
20°
15°
10°
5°
T I B E T
KASHMIR
Srinagar
Kabul
AFGHANISTAN
PUNJAB
Lahore
Amritsar
Multan
Quetta
Delhi
Meerut
Moradabad
Bareilly
RAJPUTANA
Bikaner
Jaipur
Ajmere
Jodhpur
Jaisalmer
Sind
Haiderabad
Karachi
AGRA & OUDE
Lucknow
Cawnpur
Gwalior
Allahabad
Benares
Patna
Gorakhpur
Darbhanga
Muzaffarpur
Darjiling
Lhasa
BHUTAN
BENGAL
ASSAM
Calcutta
Howrah
Ganges
Chutia Nagpur
Ranchi
Bardwan
Orissa
Puri
Ganjam
CENTRAL INDIA
Sagar
Jabalpur
Ujjain
Indore
Baroda
Ahmadabad
Kathiawar
Cambay
Surat
Satpura
CENTRAL PROV
Nagpur
Raipur
Bilaspur
Kamthi
Ellichpur
Amraoti
BERAR
Godavari
BOMBAY
Salsette I.
Poona
Ahmadnagar
HAIDERABAD
Secunderabad
Golconda
Bhima
Ratnagiri
Kistna
Masulipatam
Vizagapatam
Bellary
Karwar
Mangalore
MYSORE
Bangalore
Seringapatam
Salem
Cannanore
Tellicherry
Calicut
Nellore
Pulicat
MADRAS
Pondicherri (French)
Tanjore
Negapatam
Trichinopoli
Madura
Cochin
Travancore
Manar Gulf
C. Comorin
Jaffna
Trincomalee
CEYLON
Colombo
Kandy
Adam's Pk
Galle
Dondra Hd
ARABIAN
SEA
Laccadive Isl^ds
Maldive Isl^ds
BAY
OF
BENGAL
INDIAN OCEAN

MAP OF INDIA

Kashmir, passes Leh, the starting point of caravans across the mountains to all parts of Central Asia, and, after receiving the Shyok from the Karakorams, bends to the south near the base of Mount Godwin Austen, the second summit of Asia. It now flows between the mountains of Gilgit and Chitral on the right, across which lie difficult routes to the Pamirs and Russian and Chinese Turkestan, and the mountains of Western Kashmir on the left. Among the latter rise its tributaries, the Jhelum —whose level upper valley forms the far-famed Vale of Kashmir, with Srinagar, the summer capital, near Wuler Lake—and the Chenab. Both descend steeply to the Punjab plains, Jammu, the capital of Kashmir, being built on a tributary of the Chenab, near where it leaves the mountains.

The main stream of the Indus emerges into the high Peshawur plain, where it breaks up into a network of channels, which join up again to form one main stream near Attock, where the Kabul river comes down from Afghanistan. Here the Indus is crossed at the line from Lahore in the Punjab to Peshawur, an important military post, commanding the Khaibar route to the capital of Afghanistan by the Kabul river. Below Attock, the river, now descending rapidly in a narrow gorge, is a wild and dangerous torrent, only to be crossed by the most experienced native boatmen. At last it reaches the plains of the Western Punjab, less fertile than those of the Eastern Punjab, which are watered by the Jhelum and Chenab from Kashmir, and by the Ravi, Beas, and Sutlej from the Himalayas, all dividing into many channels—dry in early summer, but later filled by raging torrents, fed by the melting Himalayan snows. The whole region consists of wide, flat plains, bare and brown or golden with wheat, according to the season of the year. The slopes of the Himalayas, on which is Simla, the summer capital of India, add timber and tea to the resources of the Punjab.

THE MOSQUE OF AURANGZEB, BENARES, ERECTED TO EMPHASISE THE SPREAD OF MOHAMMEDANISM

The chief cities are Lahore, the capital of the Punjab, near the Ravi, with many manufactures and many radiating lines of railway; Delhi, in the Ganges basin; Amritsar, the centre of Sikh faith and influence, manufacturing Kashmir shawls; and Rawalpindi, a military station in the extreme north, between the Jhelum and Indus. The other Punjab rivers unite with the Sutlej some distance below Multan, an important town on the line between the wheat districts of the Punjab and Karachi, the port of the Indus. The united stream, known as the Punjnad, soon after unites with the main stream, and flows across the arid region of Sind, past Haiderabad, to its great delta. Karachi, the port, ships the wheat and other produce of the Punjab.

Rajputana. East of the Indus lies Rajputana, the northern part of which is a sandy desert, where camels and goats are kept wherever the scanty herbage is sufficient. Beyond the Aravalli Hills, the north-west edge of the Deccan plateau, the country improves, and has long stretches of hills and woodland, several rivers, and fertile vales and plains. The chief city of Rajputana, which is divided among native rulers, is Ajmere, at the northern end of the Aravallis.

Ganges Basins and United Provinces. The waters of the Himalayas, east of Kashmir, are carried to the Indian Ocean by the Ganges, the sacred river of the Hindus. The main stream, which has risen in the Tibetan cradle of the great Himalayan rivers, flows parallel to its tributary, the Jumna, and both break through the Himalayas in forested gorges of great beauty.

The scenery of the vast plains of the Ganges is everywhere monotonous. During the rains and in the winter months the whole of this densely populated area is covered by "an unbroken succession of fields, orchards, and mango groves surrounding clusters of villages." The Jumna flows west of the main stream past Delhi and Agra, whose magnificent palaces and temples are among the wonders of the world. Delhi, the capital of the Indian Empire, is also a manufacturing city, and a military and railway centre. Below Agra the Jumna receives the Chambul, from the Malwa plateau of the Deccan, a centre of opium and cotton culture. Allahabad is built where the Jumna unites with the Ganges, which has flowed past Cawnpore; the latter has leather and textile manufactures. The great river passes Mirzapur, the Birmingham of India, and Benares, the holy city of the Hindus, whose wonderful metal industries and fine textiles have long been world-famous. Lucknow, on the Gumti, is also a manufacturing centre, whose native cloth of gold tissues are as famous as those of Benares. Below the confluence of the Gogra is Patna, in Bengal. All this region is fertile and carefully cultivated.

The Himalayan rivers never run dry, as do those which flow from the Deccan to the right bank of the Ganges. Tea is grown on the lower slopes of the Himalayas, whose forests supply sal and other valuable timber. The

opium poppy and all Indian crops are grown, with wheat as the chief winter crop. Rice is grown in the swamp-lands during the rains. It becomes the staple crop in Bengal, the basin of the lower Ganges. The southern margin of the delta forms the Sunderbunds, a region of swampy forest or jungle, everywhere intersected by water.

Bengal. Calcutta, the capital of the Bengal Presidency, is built on the Hugli distributary of the Ganges. It is a great port, the outlet for the richest regions of India, and has considerable manufactures. During the intolerable heat of summer the Bengal Government moves to Darjiling, in the Sikkim Himalayas, commanding fine views of the giant peaks of Sikkim and Nepal, the monarch of which is Kanchenjunga. From points not far distant a glimpse of Mount Everest is caught. Both Nepal and Bhutan are independent states, occupied by hardy hill tribes, who drive their flocks to the high summer pastures and descend to the valleys in winter.

The southern margin of the Ganges basin is the wild hill-land of Chota Nagpur, with vast forests and large deposits of coal. The northern part is being cleared and cultivated, and the people live in settled villages or work in the mines. The southern part is still the home of wandering, half-civilised aboriginal tribes.

Bombay. It is difficult to state briefly the limits of the western maritime province, which includes the lower Indus basin and extends along the coast to the frontiers of Madras. Besides the alluvial plains of the coast, it takes in the western escarpment of the Deccan plateau and part of the plateau itself. Sind, in the Indus basin, has already been described. To the south is Cutch, almost cut off from the mainland by the Rann of Cutch, a broad belt of salt marshes in summer and salt desert in winter. In Gujerat and all around the Gulf of Cambay cotton is grown, with wheat as a winter crop. The hot, moist coastal plain and Western Ghats are covered with rich tropical vegetation, and on the plateau above enormous quantities of cotton are grown in the fertile black soil.

Bombay, the capital of the presidency, and rapidly becoming the first city of India, is the great market from which cotton and all Indian produce, brought down to it by many converging railways, is shipped through the Suez Canal to Europe. It is built on many islands, now practically made a peninsula by the silting up and bridging of the straits between. Its fine harbour, advantageously suited for the Suez Canal trade, its growing cotton manufactures, and its excellent railway communications ensure its permanent prosperity. On the Ghats above is Poona, the Simla of the presidency. Ahmedabad, near the Gulf of Cambay, Surat, on the Tapti, and many other towns manufacture cotton, either by hand or machine power.

Central India. Over 80 native states, the largest being Gwalior and Indore, lie around the northern margin of the Deccan, where the greatest escarpment of the Vindhya mountains faces the Aravalli hills. All are hilly or undulating. Though drier than the Ganges basin, the rainfall is sufficient for successful cultivation. Cotton and opium are grown in the hilly Malwa plateau in Indore. The summer crops are very varied, and wheat is grown as a winter crop. The chief river is the Narbada, which rises in the eastern part of the plateau and flows past Jabalpur, and through its famous gorges of white marble.

BUFFALO IN THE NOONDAY HEAT AT AGRA

Berar, under British control, lies in the upper Tapti basin, the lower course of which is in Bombay. It is a hilly region, with valuable forests and large areas of black cotton soil. The chief cotton market is Amraoti.

The Central Provinces. These include the highest part of the Deccan plateau, with the sources of the rivers flowing both east and

west. The surface consists of rugged hills and plateaux, exclosing fertile and well-cultivated plains, with much black cotton soil. The rainfall is fair, and the summers less hot than in many other parts of India, while the winters are mild. Much wheat and pulse are grown in the Narbada valley in winter, and in the rich agricultural district round Raipur, drained by the Mahanadi, replaced by rice in the rainy season. The forest produce is rich and varied. Coal is abundant. The chief towns are Nagpur, in a plain east of the Satpuras; Jabalpur, on the Narbada, and Raipur in the east.

The Native States of Haiderabad and Mysore. The large state of Haiderabad occupies the centre of the Deccan. Much of its surface consists of plains of black cotton soil, separated by low, flat-topped basalt hills. It is much drier than the Central Provinces, and there is little forest. The whole country is dotted with tanks to store water for irrigation. The rivers Godavari and Kistna cut gorges in their descent to the alluvial plains of Madras. Cotton is an important crop. Many ancient and beautiful manufactures are carried on, but as coal is abundant these may ultimately be displaced. The capital is Haiderabad, in a stony plain. Secunderabad, in the immediate neighbourhood, is a British military station.

Mysore is also a high, undulating region with many isolated rocky hills. Forests clothe the wetter western hills, producing sandalwood and other valuable timbers. Coffee is largely cultivated. Of minerals, gold is the most important. The chief cities are Bangalore and Mysore.

Madras. Nearly all the rest of India is included in Madras, the surface of which is extremely varied. The west is high, sinking to the coastal plains in the Coromandel coast in the east. In the south the forested Nilgiris, the home of little-known, aboriginal peoples, are separated from the Cardamom Hills by the Palghat Gap, an important route across Southern India traversed by a railway from Madras. The richest parts of Madras are the lower courses and deltas of the Godavari, Mahandi, Kistna, Cauvery, and other rivers from the plateau. The plateau area resembles Mysore. The mountains and hills of the west are covered with dense forests, supplying beautiful cabinet-woods. Gold and precious stones are found, but no coal. Wheat is not grown so far south, but most other Indian crops succeed. Coffee and some tea are cultivated in the western hills. The tobacco of Southern India is well known. Madras, on the surf-beaten east coast, is the third city of India. Trichinopoli, on the Cauvery delta, manufactures tobacco.

Ceylon. South of India, and not administratively included with it, is Ceylon (25,000 sq. miles). It is an island, mountainous in the centre and south, separated from the mainland by Palk Strait. The south of Ceylon is densely forested. Adam's Peak is the most famous, though not the highest, mountain. The climate is hot at all seasons, and the rainfall heavy, except in the north. Vegetation is entirely tropical in character, palms preponderating. The coconut palm supplies coir or fibre, oil, and copra —the dried flesh of the nut. Enormous quantities of tea are cultivated on the cleared hill-slopes. Many spices are also grown. Colombo, the capital and chief port, is on the west coast. Kandy is finely situated on the forested hills of the interior. Trincomalee is a port in the north-east.

Indian Islands. Rising from the seas west of Southern India are the coral Laccadive and Maldive islands. Only a few are inhabited. Vegetation consists chiefly of coconut palms. Midway in the Bay of Bengal are the forested Andaman and Nicobar Islands, the homes of primitive tribes.

Assam. The forested mountain province of Assam is traversed by the valley of the Brahmaputra, which descends from the bleak plateau of Tibet to the steamy lowlands of the Ganges delta. Much tea is grown in the clearings of the forests, which supply sal and other valuable timber. The seat of government is Shillong, in the Khasi Hills, which contain deposits of coal and petroleum.

Burma. Burma lies entirely east of peninsular India, but is practically part of that country. It occupies most of the basin of the Irawadi Upper Burma is a region of wild, forested mountains, the home of many uncivilised tribes. The forest produce is very valuable. Teak, one of the most durable of timbers, is, owing to its great weight, floated down the rivers to the coast, where elephants are used to pile it. The rubies of Upper Burma are famous for their fine colour. Petroleum is found. Lower Burma consists of the fertile deltas of the Irawadi and Salwin, both great rice-growing regions.

The Irawadi rises by several streams in the mountains east of Assam, and flows through forested hills, forming picturesque defiles in its course to the sea. It is navigable from Bhamo, 700 miles from the coast. The chief towns of the Irawadi are Mandalay, the old capital of Upper Burma, and Prome. Rangoon, the capital, on the Rangoon river, 20 miles from the sea, is connected by a creek with the delta. It has a large export trade in teak and rice. The Salwin flows from Eastern Tibet, through little-known forested mountains. In the Shan States, on the Chinese border, the cultivation of wheat is becoming important. Teak from the forests and rice from the delta are the exports of Moulmein, on the estuary of the Salwin.

INDO-CHINA

Siam. The independent kingdom of Siam occupies the region between Burma and French Indo-China, the Mekong forming the boundary between the two for a considerable distance. The Menam delta is the mainstay of Siam and the chief support of its population and trade. The capital of the country is Bangkok, a squalid little town resembling Venice, with water-streets, and houses raised on piles above the swampy delta flats.

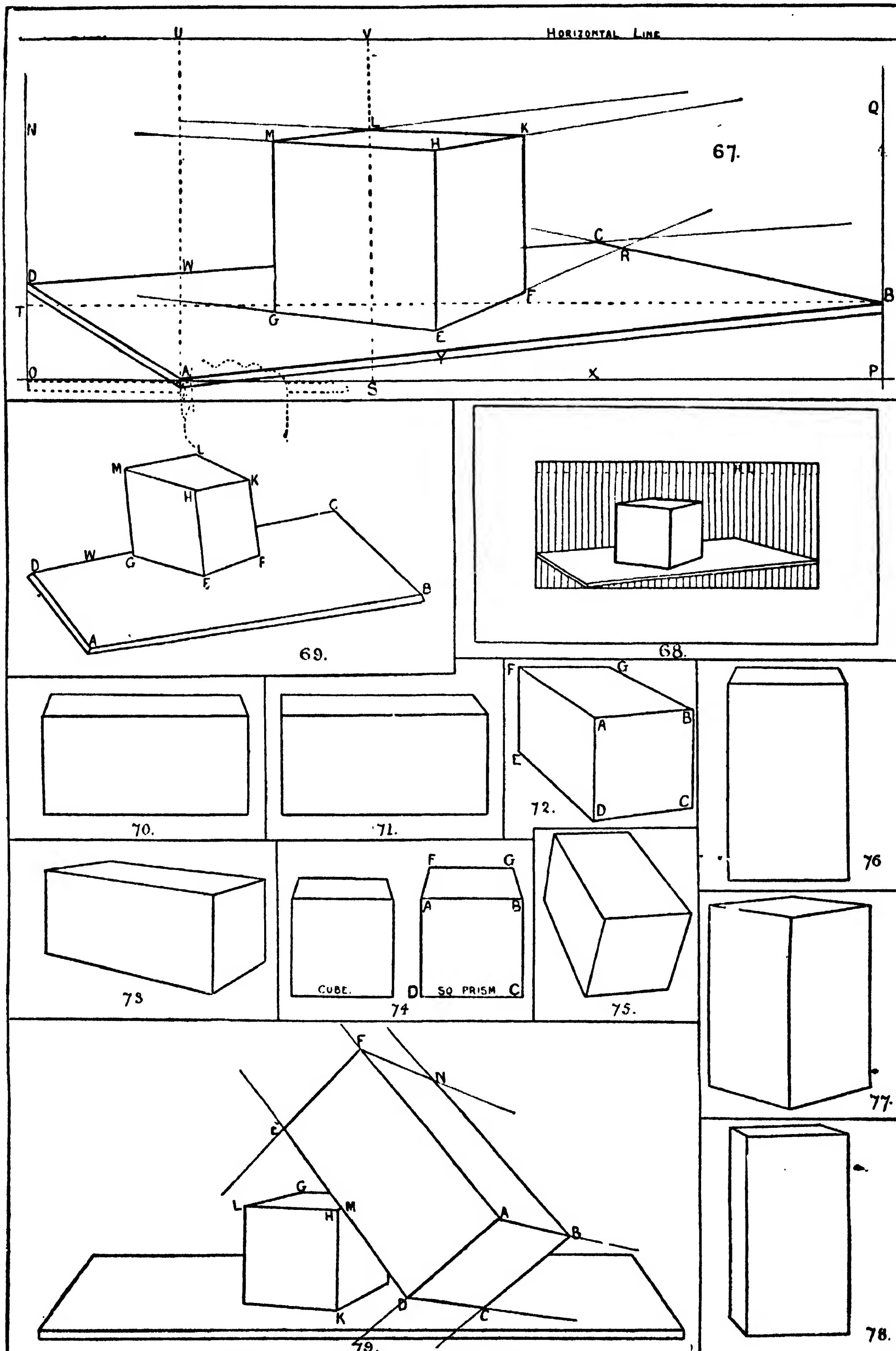
Malay Peninsula. In the extreme south of the Malay Peninsula is the British Straits Settlement, with the great port of Singapore on a neighbouring island. The Federated Malay

INDO-CHINA, ONE OF THE MOST FERTILE CORNERS OF THE EARTH

States are a British protectorate. The rest outside Burma is Siamese. The whole region resembles Burma. The rich forests supply many valuable products. Rice is the staple cultivated plant in the deltaic lowlands. The Malay Peninsula and small adjacent islands supply the world with tin.

The richest parts of French Indo-China are Tongking, the fertile delta of the Red River, with Hanoi as the capital, and Cambodia, the delta of the Mekong, which has Saigon as its capital.

A. J. AND F. D. HERBERTSON



67–79. A FIRST LESSON IN OBJECT DRAWING. DIFFERENT VIEWS OF THE SQUARE PRISM

Drawing the Cube and Square Prism. Lines, Angles, and Proportionals in Geometry. The Use of Scales.

OBJECT DRAWING AND GEOMETRY

Drawing a Simple Group. We shall now explain the method of drawing a simple group as shown in **67**. The student must obtain *real objects* from which to draw, and ought not to copy **67**, for he ought now to learn to draw from the "round." A box and a rectangular sheet of paper will serve as models. Place them upon a table at a distance of eight or ten feet away, so that the top of the cube or box is somewhat below the eye level. The objects need not necessarily be exactly of the same proportions as in **67**. The drawing should nearly fill a piece of paper not smaller than quarter imperial (15 in. by 11 in.), and larger paper will be required later. When an artist commences a sketch of a landscape he determines where the four boundaries of his picture and the position of the horizontal line will come in the scene before him. The latter can be ascertained by holding a stiff piece of cardboard horizontally, etc., as previously explained, and the boundaries by cutting in the cardboard a rectangular opening of the *same proportion* as the canvas or paper—*e.g.*, if the canvas be 15 in. by 12 in., the opening should be 5 in. by 4 in., then, holding the cardboard vertically and adjusting its distance from the eye, the four edges of the opening will show which objects of the scene will come just on the boundaries of the picture. The same method may be used with the cube and board [**68**], and more especially as a test, after judgment with the eye alone, of the proportions of the objects and the various directions of their edges.

The right and left-hand boundaries of the group [**67**] are the imaginary vertical lines *QP* through *B* and *NO* through *D*. These two vertical lines should be drawn first, about an inch from the edges of the drawing-paper, which ensures the paper being fairly well filled with the drawing, and also determines the scale of the latter.

Importance of True Proportion. All representations of masses, edges, etc., must henceforth be kept in true proportion with this scale. Now make a few preliminary, but careful and searching observations of the general proportions—*e.g.* the width *OP* or *TB* of the group is about three and a third times the height *LS*; the vertical edge *EH* is very nearly equidistant from the corners *D* and *B*; the edge *GM* about midway between the corner *D* and the edge *FK*; and the corner *A* is much nearer to the left-hand side of the group than to the right. All these measurements are of course only as they seem to the eye from the point of observation; they are the *apparent* not the *real* distances.

The student must assiduously persevere in making these and every judgment first with the eye alone, and afterwards test by measuring with the pencil held as already advised. The mind being stored with these important facts, the exact position of the corner *A* should be observed by comparing the distance *OA* with *AP*. It will be found that *AP* is about four and a half times *OA*. In testing this the ascertained length *OA* should be carefully stepped along *AP*, and it is most important that the pencil should be held correctly, (see dotted line drawing of hand and pencil in **67**), *not* slanting away because the edge recedes.

The Three Most Important Points. The position of *A* should now be marked on the drawing paper, by making the space between it and *QP* four and a half times that between it and *NO*. Do not use the cumbersome and unsatisfactory method (which does not train the eye) of taking a measurement from the objects and then some multiple of it to suit the scale of the drawing. Next obtain the slope of the edges *AB* and *AD*, by observing that the corner *B* is *apparently* slightly lower than *D*, the apparent size of the space between *O*—level with *A*—and *D* is two-twirds of *OA*, and that *PB* is about one-fifth less than *OD* or a little more than one half of *OA*. To test, hold the pencil *vertically* to obtain apparent length of *OD* and *PB*, and *horizontally* to compare them with *OA*. Then mark these positions on the respective vertical lines in the drawing, in the same proportion with *OA* already obtained, and the three most important points are thus determined.

Now fix the position of the *horizontal line* by comparing the distance *AU* with *AP*, and as a check *LV* with *AO*. Then draw the lines *AB* and *AD*; these, if continued to the line *HL* extended, would give their respective vanishing points, which are, as in **67**, very often outside the limits of the drawing-paper, but with care their position may be judged. Afterwards draw *DC* very slightly converging with *AB*, and *BC* more quickly with *AD*. The larger the angle at which parallel edges recede the more quickly they appear to converge, as *AD*, *BC*; and the more nearly they appear horizontal, as *AB*, *CD*, the less quickly they converge. The intersection of *BC* with *DC* gives the position of *C*.

Next apply a few tests to the drawing, as any inaccuracy not corrected at this stage will cause great trouble when drawing the cube. For instance, test by holding the pencil vertically, whether the distance *AW* from the front corner to the back edge is in true proportion with *AO*, not as in **69**; and that the back corner *C* is opposite a point on the front edge, so that *XP* is two-fifths of *AP*, or two-thirds of *AX*. Then sketch the lines to show the thickness of the

board, and keep the very short lines at the corners *vertical*, not as in **69**.

Drawing the Cube. In drawing the cube, first determine the position of the corner *E*, by comparing the space between *D* and *E* with that between *E* and *B*, or *AE* with *AD*, or *AE* with *EB*. *E* is much nearer to the front edge at *Y* than it is to the back, and is nearly equidistant from *D* and *B*. In **69** the position of *E* is quite wrong. Now draw the lines *EF* and *EG*. The board being correctly drawn, it is quite easy to determine the *direction* of the two edges which they represent, for it will be noticed that *EF* recedes towards a point *R* not far from the corner *C*, and *EG* directly towards the corner *D*. Next ascertain the *apparent* length of *EF*, which is about equal to the distance *FC*, and of *EG*, which is about two-thirds of *GD*. Then draw a vertical line through each of the points *G*, *E*, and *F*, also observe that *EH* is *apparently* rather longer than *EG*. The height of *GM* and *FK* can easily be settled by drawing *HM* converging with *EG*, and *HK* with *EF*, to their respective vanishing points. From *M* draw *ML* converging with *HK* and *EF*, and from *K* draw *KL* converging with *HM* and *EG*, thus obtaining the apparent shape of the top surface. Do not be afraid of producing these lines some distance right and left, as in **67**, in order to see whether they are converging properly. Now hold the drawing vertically at arm's length, compare it carefully with the group of objects, correct any inaccuracies, clean up, and finish with a soft, broad, grey line.

The Secret of True Drawing. The secret of making a true drawing lies in the most careful and searching observation of the proportions between various spaces, and the proper convergence of lines which represent what are really parallel edges. Do not be satisfied with a comparison between one part and *one* other, but make it between one part and *several* others. The mistakes generally made are such as are shown in **69**, where, besides those already mentioned, *AB* and *DC* are diverging instead of converging towards the right, and *AD*, *BC* do not converge to the left, thus causing the board to appear warped and wider at the right end. The edges *EF*, *HK*, are converging towards the right, but *ML* is not; also *EG*, *HM*, *KL*, are not converging towards the left, while *GM*, *EH*, *FK* ought to be vertical. If the invisible back edges were represented it would be seen that the back corners of the cube would appear to be beyond the back edge of the board. The space *DG* is too small, *AD* is too long and slanting in the wrong direction. The point *A* is too far to the left. There are other errors which an observant eye will easily detect.

The Square Prism. In **70** to **78** we give various appearances of the square prism, an object which is square at its ends, and has an oblong for each of its four side surfaces. The method of drawing this is similar to that of the cube, but special attention should be given to the fore-shortening of the long edges in particular views, as in **72** and **74**, where the long edges *AF*, *BG*, *DE*, are represented by shorter lines than *AB*, *BC*, *CD*, *DA*, those for the short edges. Compare the drawing of the cube with that of the square prism in **74**; both are views seen when the spectator is directly opposite the square surface, but the objects are below the eye level.

Figure **75** represents the prism resting on one of its short edges. In **79** we have a more difficult view of the prism resting on one of its corners on the board, and its under surface leaning against one top edge of the cube. The board and cube will give little trouble to draw, but observe that the front and back edges of the board do not converge, because they are not receding from the observer, while the side edges do so rapidly. In this case we have the two extremes, one where apparent convergence takes place most rapidly and the other where there is no convergence at all. The student should place the objects as indicated, and observe that the edges *AB*, *DC*, *FN* are apparently converging downwards to the right, *AD*, *BC*, *FE* downwards to the left, and *AF*, *BN*, *DE* upwards to the left. Even without a knowledge of advanced perspective the position of each set's vanishing point can be determined, if careful attention be given to the apparent direction of any two edges in each set.

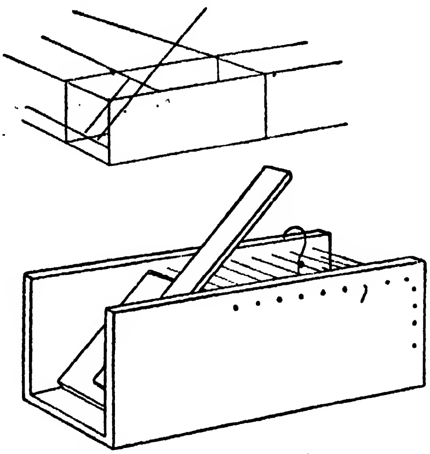
Drawing the Prism. Assuming that the board and cube are drawn, begin the drawing of the prism by obtaining the position of the corner *A*, and next the slant and length of the three edges *AB*, *AD*, *AF*, each of which belongs to a different set. Notice that *D* is rather higher than *K*, and *KD* is about two-thirds of *KH*; *AB* is three-fifths of *AD*; while *AF* is three times as long as *AB*; and the corner *C* is almost vertically under *A* and level with *K*, thus determining the direction of *BC* and *DC*. The point *E* is to the left of *G*, but higher, and the distance *EG* is equal to *KD*, which gives the direction of *FE* and *DE*. The direction of *DE* could be found by observing where it cuts the edge *HM* of the cube. Draw *FN* converging with *AB* and *DC*, and *BN* converging with *AF* and *DE*. Each set should converge as shown in **79**.

Having mastered these geometrical solids, the student should draw from objects similar in construction; such as rectangular boxes, bricks, books, stools, chairs, tables, doors, cupboards, steps, easels, tanks, and picture frames. Some of these are shown in **80** to **85**. He should analyse each object and endeavour to find some simple lines of construction; draw these first correct in proportion and perspective, as indicated by small sketches in **80** to **85**, the study of which will teach him much more than hundreds of words.

PRACTICAL GEOMETRY

Lines, Angles, and Proportionals. The following are preliminary exercises which will often be required in succeeding problems:

86. To Bisect a given Line *AB*. The best way is to do it by trial with the compasses. Another method, **86** *A* and *B*. With centre *A* and any radius longer than half the line describe an arc. With centre *B* and same radius intersect it in *C* and *D*. Draw *CD* which bisects the given line at right angles.



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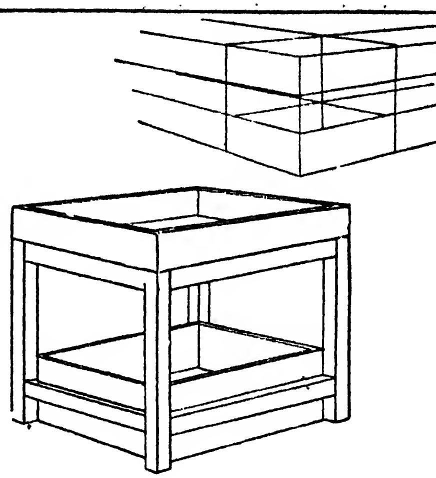

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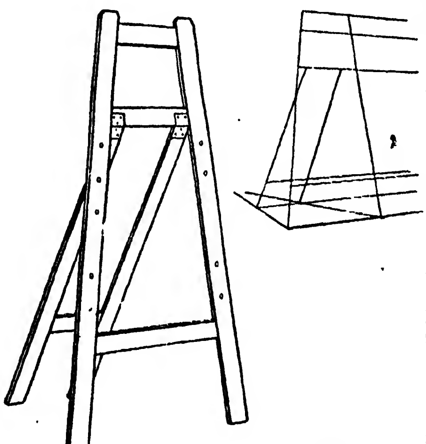

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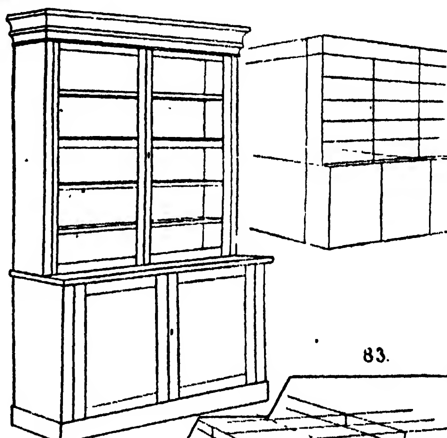

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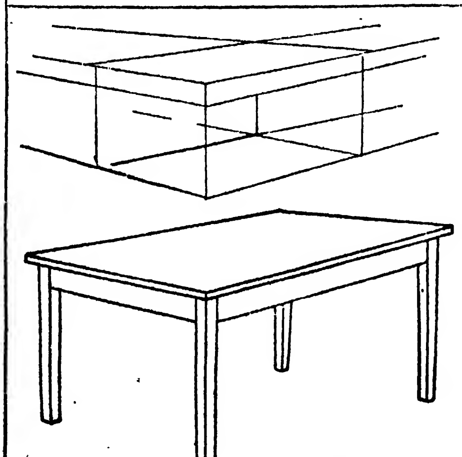

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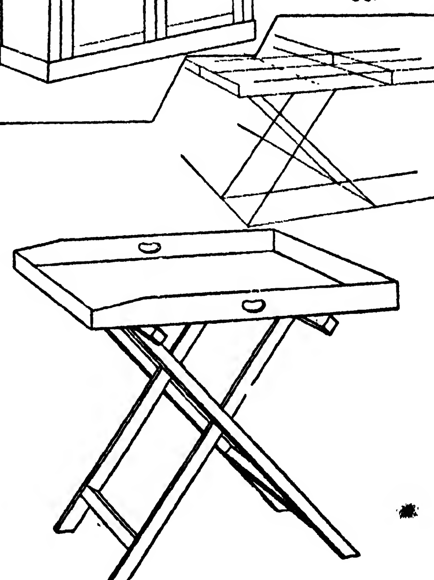


85.

80-85. EXAMPLES OF OBJECTS DRAWN ON THE SAME PRINCIPLES AS THE CUBE AND SQUARE PRISM

87. To Draw a Perpendicular to a given Line *AC*, from a given Point *A* within or *B* without the Line. This may be done in several ways by intersecting arcs, but the most practical, most accurate, and quickest is by placing a ruler level with the line *AC*, and a set square with one of the edges exactly touching the ruler, and the other passing through the given point as shown in **87**.

88. To Bisect a given Angle *ABC*. With centre *B* and any radius describe an arc to cut the lines in *A* and *C*. With centres *A* and *C* and any radius describe arcs to intersect in *D*. Draw *BD* which bisects the angle. By this means an angle may be divided into 4, 8, 16, etc., equal parts.

89. To Trisect a Right Angle *ABC*. With centre *B* and any radius describe the arc *AC*. With centres *A* and *C* and same radius cut the arc in *D* and *E*. Draw *BD* and *BE* which trisect the right angle.

90. To Draw a Line parallel to another *AB*, at a given Distance *C* from it, or through a Given Point *D*. At any point in *AB* draw a perpendicular *GF* equal to the distance *C*. Place one edge of a set square level with *AB*, then a ruler against another edge of the set square [**90**]. Hold the ruler firmly fixed, but slide the set square along it until the edge (which was level with *AB*) passes through *F*, and draw *FE* the required line. When the point as *D* is given, the method is the same except that no perpendicular is required [**90**].

91. To make an Angle Equal to a Given Angle *ABC*. Draw any line *EF*. With centre *B* and any radius describe the arc *AC*. With centre *E* and same radius describe the arc *DF*. With distance *AC* as radius and *F* as centre cut the arc in *D*. Draw *ED* through *E* and *D* (Euc. III. 27).

92. Through a Given Point *C* to Draw a Line meeting a Given Line *AB* at an Angle equal to a Given Angle *H*. Through *C* draw *CF* parallel to *AB*. At *C* make the angle *FCD* equal to *H*, and the angle *CDB* will also be equal to it (Euc. I. 29).

93. To Bisect the Angle made by Two Converging Lines *BA*, *DC*, without using the Apex. Draw a line at any convenient distance parallel to *AB*, and another at same distance parallel to *CD* to intersect in *E*. Bisect the angle thus obtained.

94. Through a Given Point *E* to Draw a Line converging to the Same Point at which Two other converging Lines would meet if Produced. Draw any two convenient lines *FG*, *HK* parallel to each other and cutting both *AB* and *CD*. Join *E* and *F*, *E* and *G*. Through *H* draw *HL* parallel to *FE*, and through *K*, *KL* parallel to *GE*, intersecting at *L*. Draw *EL* through *E* and *L*.

95. In a Given Line *AB* to find a Point Equidistant from Two Given Points *C* and *D* without it. Join *C* and *D*, and bisect the line *CD* by a perpendicular meeting *AB* in *E*, which is the required point.

96. To Draw Two Straight Lines to Meet a Given Line *CD* from Two Given Points *A* and *B* without it, and to Make Equal Angles with it. Draw *AE* perpendicular to *CD* so that *FE* equals *FA*. Draw *BE* cutting *CD* in *G*. Draw *AG*. Then *AG* and *BG* are the required lines.

Proportionals. If a straight line be drawn parallel to one side of a triangle, it cuts the other two sides or those produced proportionally. (Euc. VI. 2).

97. To Divide a Line *AB* into any Number of Equal Parts (say Seven). Draw *AC* at any angle with *AB*, and set off on it any convenient distance seven times. Join 7*B* and from the points 6, 5, 4, 3, 2, 1, draw parallels to 7*B* to cut *AB*.

98. To Divide a Line *AB* proportionally to a Given Line *CD*. Draw *AE* at any angle with *AB*. Make *A*1, 1 2, 2 3, 3*E* equal to *C*1, 1 2, 2 3, 3*D* respectively. Join *E* and *B*. Draw parallels to *EB* through 3, 2 and 1 to meet *AB*.

99. To Divide a Given Line *AB* in the Same Proportion as the Nos. 3, 5, and 2. Draw *AC* at any angle with *AB*, and set off on it 3 + 5 + 2 equal parts. Join 10 and *B*, and through 3 and 8 draw parallels to 10*B* to meet *AB*. Then *AD* : *DE* : *EB* are as 3 : 5 : 2.

100. To Find a Fourth Proportional (Greater or Less) to Three Given Lines *A*, *B*, and *C*. Draw *DG* and, at any angle with it, *DH*. Set off *DE* equal to *A*, and *DF* equal to *B*. Join *E* and *F*. Set off *EG* equal to *C*. Through *G* draw *GH* parallel to *EF* cutting *DH* in *H*, then *FH* is the fourth proportional *greater*—*i.e.*, *DE* : *DF* : : *EG* : *FH*. When the fourth proportional *less* is required, use the same method, but commence with the *longest* line.

101. To Find a Third Proportional (Greater or Less) to Two Given Lines *A* and *B*. This is the same as finding the fourth proportional to three given lines, the last two of which are equal (*e.g.*, *A* : *B* : : *B* : required line). Proceed as in **100**, but remember *B* is used twice (in **101**, *CF* and *CD* each equal *B*). *CE* is the required third proportional *greater*. For the third proportional *less*, commence with *B* and use *A* twice.

102. To Find a Mean Proportional to two Given Lines *A* and *B*. On a straight line make *CD* equal to *A*, and *DE* equal to *B*. Bisect the whole line *CE* in *F* and describe a semicircle with *F* as centre and *FC* or *FE* as radius. At *D* draw *DG* perpendicular to *CE* to meet the arc in *G*. Then *DG* is the mean proportional—*i.e.*, *CD* : *DG* : : *DG* : *DE*, or *A* : *DG* : : *DG* : *B*.

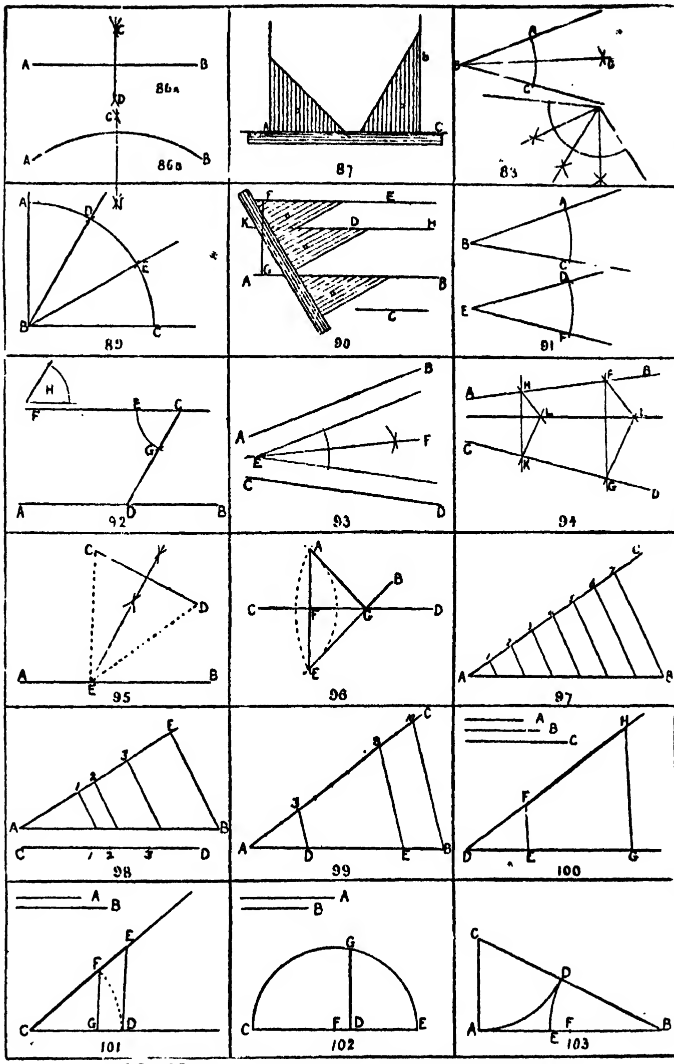
103. To Divide a Line *AB* into an Extreme and Mean Ratio—*i.e.*, so that one part shall be a mean proportional between the whole line and the other part. Draw *AC* perpendicular to *AB* and equal to half of it (*AF* or *FB*). Join *B* and *C*. Make *CD* equal to *CA*. With centre *B* and radius *BD* cut off *BE*. Then *AB* is divided at *E* so that *AE* : *EB* : : *EB* : *AB*, or so that the rectangle *AE*, *AB*, equals the square on *EB* (Euc. VI. 30 and II. 11).

Scales. It is often necessary to make drawings larger or smaller than the objects represented. It would be very inconvenient to draw the plan of a building full size, as it would be too

large for practical use; but if it were drawn smaller, with the same ratio in all its parts, it would enable anyone to tell the relative size or proportion of all parts. To obtain these proportions correctly a scale is used. Thus, if for every foot on the building we use one inch on the drawing, the latter would be $\frac{1}{12}$ the size of the building, or we say the scale of the drawing is one inch to the foot. The $\frac{1}{12}$ is called *the representative fraction*, because it indicates the ratio each line of the drawing bears to the object represented.

There are occasions when it is advisable to make the drawing larger than the object, such as the details of the small parts of a watch, clock, and small instruments.

The simplest form of a scale is one of equal parts, and is called a *plain scale*. All scales must be constructed with very great care, and drawn with a very sharp pencil or fine pen to ensure absolute accuracy. By studying a few examples the student will soon understand their construction and use.



86-103. LINES, ANGLES, AND PROPORTIONALS

Plain Scales. 104. To Draw a Scale of $\frac{3}{4}$ in. to 1 ft. to Measure 6 ft. and Show Feet and Inches. Draw two parallel lines about $\frac{1}{16}$ in. apart. Set off $\frac{3}{4}$ in. six times, then each of these parts represents 1 ft. Divide the first part into 12 equal divisions, each of which will represent 1 in. When figuring and naming the parts it is important that the *zero* should be placed as shown, so that dimensions may be taken off readily with the dividers. Thus, to take off 3 ft. 8 in., place one leg of the dividers on point 3 ft. and the other on 8 in. The distance between the legs represents 3 ft. 8 in. The representative fraction is obtained thus:

$$\frac{\frac{3}{4}\text{ in.}}{1\text{ ft.}} = \frac{\frac{3}{4}\text{ in.}}{12\text{ in.}} = \frac{3}{48} = \frac{1}{16}$$

105. To Construct a Scale of $1\frac{1}{2}$ in. to 1 yd. to Measure 3 yds. and Show Yards and Feet. Draw two parallel lines as before. Set off $1\frac{1}{2}$ in. three times, and divide the first part into three equal divisions, which represent feet. Representative fraction:

$$\frac{1\frac{1}{2}\text{ in.}}{1\text{ yd.}} = \frac{\frac{3}{2}\text{ in.}}{36\text{ in.}} = \frac{3}{72} = \frac{1}{24}$$

106. Draw a Scale of $2\frac{1}{4}$ in. to 1 mile to Show Miles and Furlongs, and to Measure 2 Miles. Draw two lines as before. Set off $2\frac{1}{4}$ in. twice to represent miles, and divide the first part into eight equal divisions, which represent furlongs.

Diagonal Scales. These are used when the divisions become very minute. From **107** it will be seen that the construction is based upon the principle of similar triangles. Let the rectangle *ABCD* [**107**] be divided into four equal parts by parallels to *AB*, and the diagonal *BD* be drawn, then a number of similar triangles will be formed. Thus the triangles *CBD* and *JBF* are similar; therefore if *BJ* is half of *BC*, then *JF* is half of *CD*. In the same way *KE* is one-quarter of *CD*. As *CD* may be as small as we like, it can be easily realised how valuable this principle is. From a *plain* scale we obtain two dimensions, such as miles and furlongs, or yards and feet, but from a *diagonal* scale we may obtain three dimensions, such as yards, feet, and inches.

108. Draw a Diagonal Scale Showing Inches, Tenths, and Hundredths of an Inch, and to Measure 4 in. Draw a line and mark off on it four separate inches. Divide the first inch into 10 equal parts for tenths of an inch, then on a perpendicular erected at 10 set off 10 equal parts to any convenient unit, and through each draw parallels to the first line. Erect perpendiculars at 0, 1, 2, and 3; join 9 and B, and through each division for tenths of an inch draw the other diagonal lines parallel to $9B$ as shown. The distance CD is $\frac{1}{100}$, EF is $\frac{8}{100}$ of an inch, and GH is $2\frac{27}{100}$ in. or 2·27 in.

109. Draw a Scale of $\frac{1}{48}$ to Show Yards, Feet, and Inches, and to Measure 6 yds. This $\frac{1}{48}$ means $\frac{3}{4}$ in. to a yard, for $\frac{1}{48}$ of 1 yd.

$$= \frac{1}{48} \times \frac{36}{1} \text{ in.} = \frac{36}{48} \text{ in.} = \frac{3}{4} \text{ in.}$$

Draw a line, and mark on it $\frac{3}{4}$ in. six times, to represent yards. Divide the first division into three equal parts for feet. On a perpendicular erected at 3 feet set off 12 equal parts of any convenient unit, and through each part draw parallels as before. Erect perpendiculars at 0, 1, 2, 3, 4, and 5 yards. Join 2 ft. and 12 in., and draw other diagonals parallel to it. Figure and name divisions on scale as shown. AB represents 3 yd. 1 ft. 8 in.

Scale of Chords. This is used for measuring angles, and is marked on a ruler or protractor by the letters CH or CHO. The best way to know how to use this scale is to learn its construction.

110. Make a quadrant ABC. Divide the arc AC into nine equal parts of 10° each. The divisions 10, 20, 30, etc., on AD are found by taking A as centre with radius $A10$, $A20$, $A30$, etc., on arc AC, and marking them from A along AD as shown by concentric arcs. The distance from A to each division on AD is the chord of the angle containing that number of degrees. The divisions become smaller as they approach 90°. The distance 0 to 60 is *always* the radius of the arc to be used in making any angle.

Thus, to make an angle of 30°, draw any straight line AB as in **110a**. With either end, as A, as centre, and radius $A60$ in **110**, describe an arc CD. With C as centre and $A30$ in **110** as radius cut CD in D. Join AD, then DAC is an angle of 30°.

111. The Sector. This instrument is formed of two flat legs hinged at O. Lines OL are drawn radiating from O, one on each leg, and are called *the line of lines*, by the use of which problems in proportion can be readily solved. There is also *the line of polygons*, marked POL. Care must be taken to measure always from points on the lines (thick in illustration) drawn from the centre O. The following five problems show some of its uses.

To Bisect a Line. Open the sector until the transverse distance from, say, 8 to 8 on OL equals the given line. Then the distance from 4 to 4 is half the line.

To Divide a Straight Line into Five Equal Parts. Open the sector until the transverse distance from 5 to 5 on OL equals the straight line, then the distance from 1 to 1 will be $\frac{1}{5}$ of the given line.

Find x in the Proportion $2 : x :: 5 : 2\frac{1}{4}$. With the dividers measure $2\frac{1}{4}$ in. Open the legs of the sector until the distance between 5 on OL of one leg and 5 on OL of the other is $2\frac{1}{4}$ in. Then the transverse distance between 2 and 2 on OL is the required distance x.

112. To Inscribe a Regular Heptagon in a Circle. Open the sector until the distance from 6 to 6 on POL equals the radius CD of the circle. Then the transverse distance from 7 to 7 on POL is the side of the heptagon.

113. To Construct a Regular Pentagon on a Given Line AB. Open the sector until the transverse distance from 5 to 5 on POL equals AB. With A and B as centres, and the transverse distance from 6 to 6 as radius, make arcs intersecting at C. With centre C and same radius describe a circle. Set off AB round it.

Use of Scales. 114. To Construct an Irregular Polygon from a Rough Diagram, the Dimensions on a Diagonal AE, and the Ordinates bB, cC, dD, etc., being Given. $AE = 9$ ch., $Ah = 1$ ch. 30 l., $Ab = 2$ ch., $Ag = 4$ ch., 40 l., $Ac = 6$ ch. 30l., $Af = 6$ ch. 80 l., $Ad = 7$ ch. 15 l. The ordinates $hH = 2$ ch. 60 l., $gG = 1$ ch. 25 l., $fF = 2$ ch. 20 l., $dD = 1$ ch. 60l., $cC = 1$ ch. 10l., and $bB = 2$ ch. 80 l. Scale, $\frac{1}{2}$ in. to 1 ch.

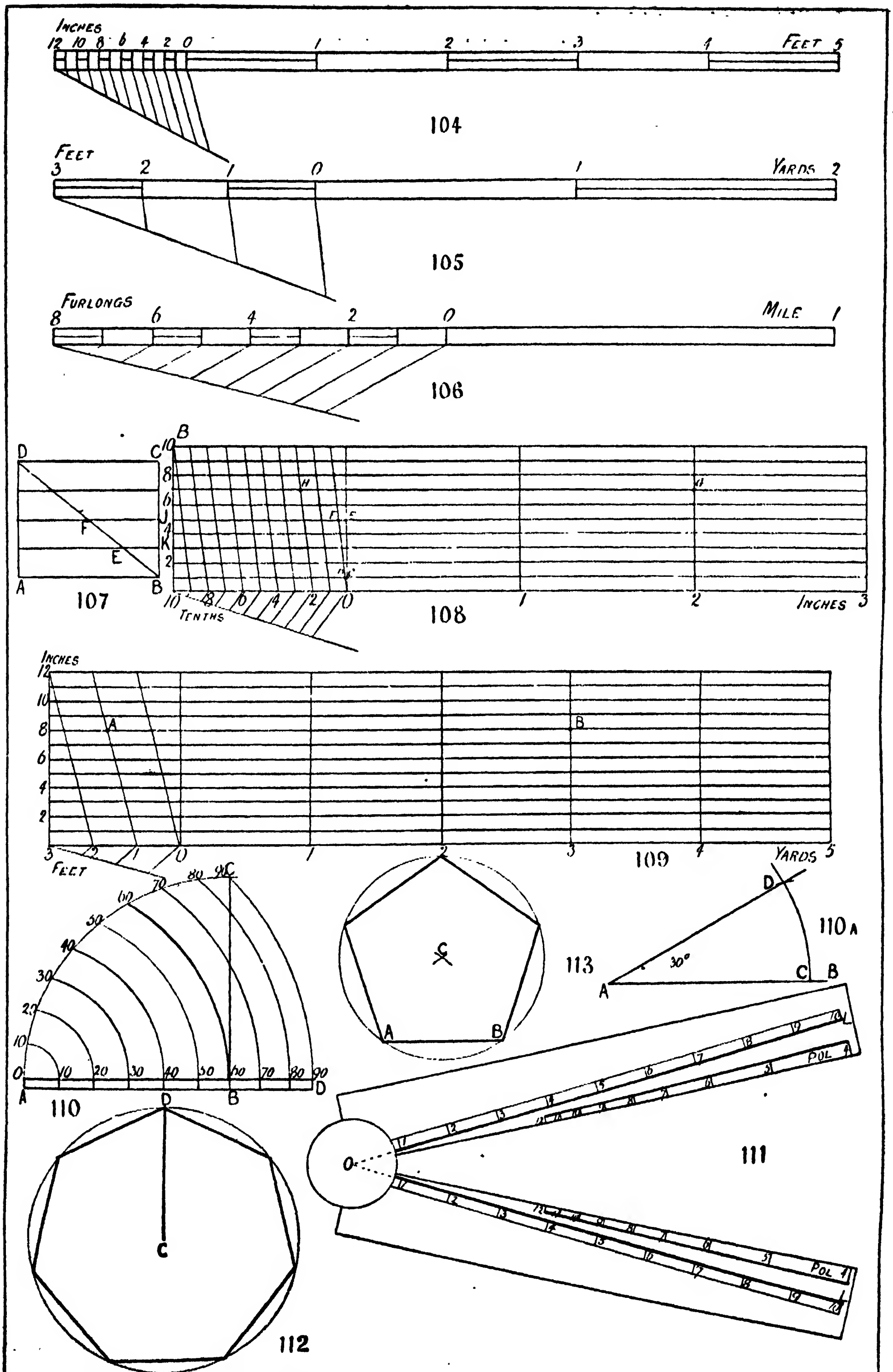
First construct the scale as shown. The diagonal scale is for obtaining measurements of 5, 10, or 15 l. Draw AE, 9 ch. long, according to scale, then set off Ah, Ab, Ag, etc., on it. At the points h, b, g, c, etc., erect the ordinates according to scale. Join A, B, C, D, E, F, G, and H.

115. To Enlarge or Reduce a Drawing by a Proportional Scale. Say, to enlarge the given drawing of a gate, so that AB shall be $2\frac{1}{2}$ in. First construct the proportional scale by drawing the two lines AB and Ab at any angle with each other, making $AB = AB$ and $Ab = 2\frac{1}{2}$ in. Mark the several distances on small drawing on AB. Join B and b, and through H, D, E, F, C, and G draw parallels to Bb as shown. Then the respective measurements along Ab are the required ones for the various parts for larger drawing.

116. To Enlarge a Map. Make a proportional scale as before, and as shown in **116**. Set out the squares for the larger map according to enlarged scale, and then draw the map so that all parts come in corresponding positions in the larger squares to those of smaller squares.

Triangles. 117. To Construct an Equilateral Triangle on a Given Straight Line AB. With centres A and B and AB as radius, describe arcs intersecting at C. Join AC and BC. Then ABC is the triangle required. (Euc. I.1.)

118. To Construct a Triangle with Sides 2·5 in., 1·8 in., and 3 in. First draw one side, say, $AB = 3$ in. as base; with A as centre and a radius of 2·5 in. describe an arc, and with B as centre and 1·8 in. as radius, describe another



104–113. PLAIN AND DIAGONAL SCALES. SCALE OF CHORDS. SECTOR

arc cutting the other in C. Join AC and BC, which complete the triangle required.

119. To Construct an Isosceles Triangle, the Base AB and the Altitude CD being Given. Bisect AB in E, and at E erect a perpendicular EF, equal to CD. Join FA and FB. Then AFB is the triangle required.

120. To Construct an Isosceles Triangle having Given the Vertical Angle CDE and the Base AB. With D as centre and any convenient radius cut off DC equal to DE. Join CE. At A and B make angles each equal to ECD or CED. Then AFB is the triangle required.

121. To Construct an Isosceles Triangle, the Vertical Angle C and the Altitude AB being Given. Draw DE perpendicular to AB. Bisect the angle C. At B construct an angle on each side of AB each equal to half the angle C. DEB is the required triangle.

122. To Construct a Triangle, the Base AB and the Ratio 2 : 4 : 3 of the Angles being Given. Produce AB any length. With A or B as centre, describe a semicircle and divide it into nine equal parts (2 + 4 + 3). Draw AC through 2. Join $A4$. Through B draw BC parallel to $A4$, meeting AC in C. ABC is the triangle required.

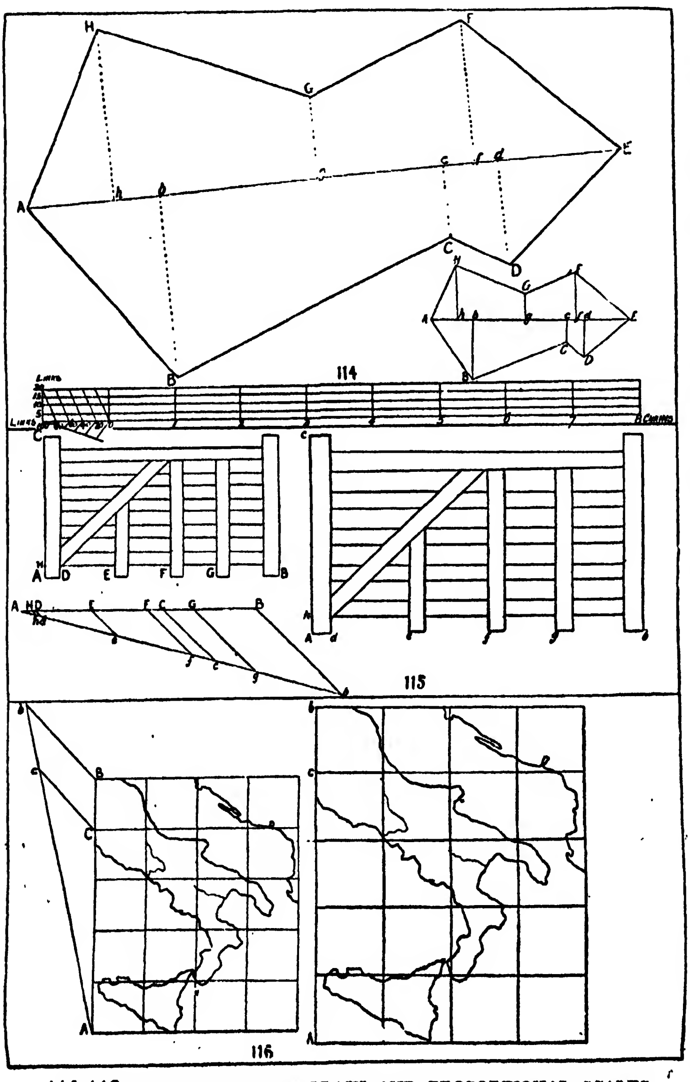
123. To Construct a Right-angled Triangle, the Base GH and Hypotenuse CD being Given. Take a line AF equal to CD as diameter, and bisect it in E. With E as centre, describe a semicircle FBA. With A as centre and GH as radius, cut the semicircle in B. Join BF and AB. Then ABF is the triangle required, and it has the right angle at B. (Euc. III. 31.)

124. To Construct a Right-angled Triangle, the Hypotenuse AB and an Acute Angle C being Given. Bisect AB in D. With D as centre describe a semicircle on AB. At A construct an angle BAE equal to C. Join BE. ABE is the triangle required. (Euc. III. 31.)

125. On a Given Base, AB, to Construct a Triangle similar to a Given Triangle, CDE. Make the angles at A and B respectively equal to those at C and D. Then ABF is the triangle required.

126. To Construct a Triangle, the Altitude CD and the Base Angles A and B being Given. Through C and D draw lines EF and GH perpendicular to CD. At C make the angle ECG equal to A and FCH equal to B. CGH is the triangle required.

127. To Construct a Triangle, the Base AB 1·75 in. Long, the Vertical Angle C 30°, and the Altitude 1·5 in. being Given. Bisect AB in D, and erect a perpendicular at D. At either end of AB make an angle of 60° (90°—angle C, 30°), intersecting the perpendicular at E. With centre E and radius EA draw the arc $ABFG$. Draw FG parallel to AB and 1·5 in. from it. Join FA and FB. ABF is the triangle required. The angle at the centre is always twice the angle at the circumference; thus, the angle AEB is twice the angle AFB. (Euc. II. 20.)



114-116. APPLICATION OF PLAIN AND PROPORTIONAL SCALES

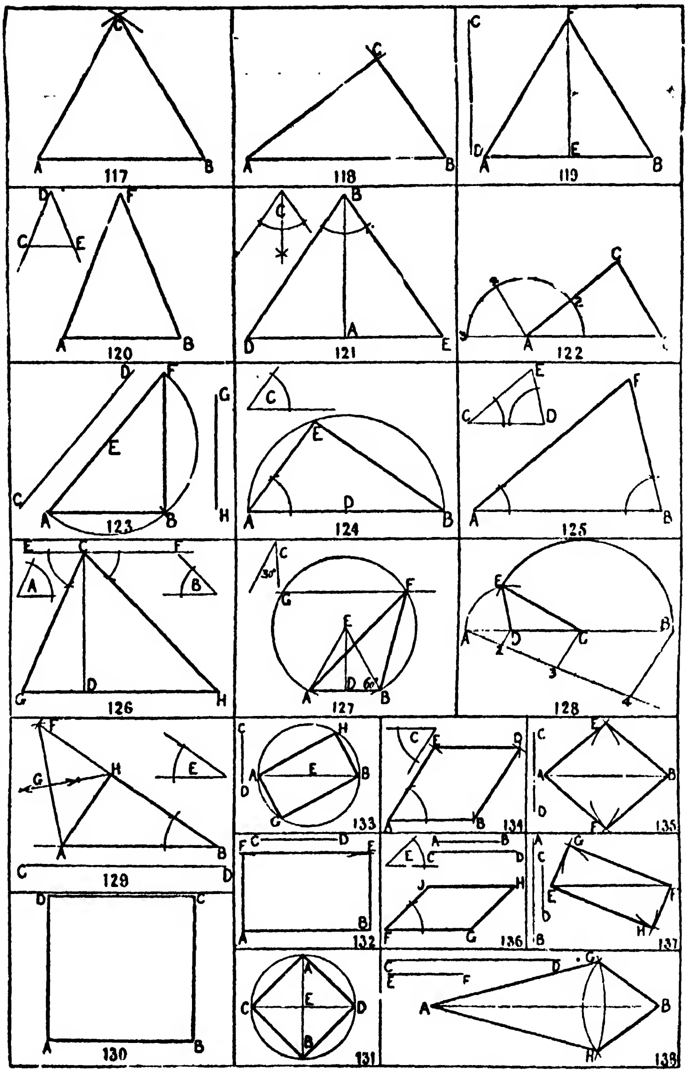
128. To Construct a Triangle whose Perimeter shall be equal to a Given Line *AB*, and the Sides in the Proportion 2 : 3 : 4. Divide *AB* in the proportion 2 : 3 : 4 as shown. With *D* and *C* as centres, and *DA* and *CB* as radii respectively, describe arcs intersecting at *E*. Join *DE* and *CE*. Then *EDC* is triangle required.

129. To Construct a Triangle, the Base *AB*, the Sum *CD* of the other Two Sides, and One of the Base Angles *E* being Given. At *B* make an angle *ABF* equal to *E*. Make *BF* equal to *CD*. Join *FA* and bisect it by the perpendicular *GH* cutting *FB* in *H*. *ABH* is the triangle required.

Quadrilaterals. **130.** To Construct a Square, the Side *AB* being Given. At *A* and *B* erect the perpendiculars *AD* and *BC* respectively, each equal to *AB*. Join *CD*.

131. To Construct a Square, the Diagonal *AB* being Given. Bisect *AB* by the perpendicular *CD*. With centre *E* and radius *EA*, describe a circle cutting *CD* in *C* and *D*. Draw *AD*, *DB*, *BC*, and *CA*.

132. To Construct an Oblong or Rectangle, the Two Sides *AB* and *CD* being Given. At *A* and *B* erect the perpendiculars *AF* and *BE* respectively, each equal to *CD*. Join *EF*.



117-138. TRIANGLES AND QUADRILATERALS

133. To Construct an Oblong, the Diagonal *AB* and One Side *CD* being Given. Bisect *AB* in *E*. With centre *E* and radius *EA* describe a circle. With centres *A* and *B* and radius *CD* cut the circle in *G* and *H* on opposite sides of *AB*. Join *AG*, *GB*, *BH*, and *HA*.

134. To Construct a Rhombus, the Side *AB* and One of the Angles *C* being Given. At *A* make an angle equal to *C*, and make *AE* equal to *AB*. With centres *B* and *E* and radius *AB* describe arcs intersecting at *D*. Join *BD* and *ED*.

135. To Construct a Rhombus, the Diagonal *AB* and One Side *CD* being Given. With centres *A* and *B* and radius *CD* describe arcs intersecting at *E* and *F*. Join *AE*, *EB*, *BF*, and *FA*.

136. To Construct a Rhomboid, the Two Sides *AB*, *CD*, and an Angle *E* being Given. Draw *FG* equal to *CD*. At *F* make an angle equal to *E*. Make *FJ* equal to *AB*. Through *J* draw *JH* parallel to *FG*, and through *G* draw *GH* parallel to *FJ*, cutting *JH* in *H*.

137. To Construct a Rhomboid, the Diagonal *EF* and the Two Sides *AB* and *CD* being Given. With centres *E* and *F* and radius *AB* describe arcs on opposite sides of *EF*. With the same centres and radius *CD*, describe arcs on opposite sides of *EF* intersecting the first arcs in *G* and *H* respectively. Join *EG*, *GF*, *FH*, and *HE*.

138. To Construct a Trapezium, the Diagonal *AB* and Two Pairs of Equal Sides *CF* and *EF* being Given. With centre *A* and radius *CD* describe an arc. With centre *B* and radius *EF* describe another arc intersecting the first in *G* and *H*. Join *AG*, *GB*, *BH*, and *HA*.

WILLIAM R. COPE

The Four Elements Required in Food. The Amount of Food a Man Needs, and the Energy Produced from It. Chittenden's Experiments. Tablet Food. Mastication.

FOOD AND HEALTH

In the previous chapter we pointed out that the foundation of health, conceived as energy, is the energy of the sun contained in the foods of which our tissues are built. In order, then, to have anything like an adequate understanding of the principles and laws of health, we must begin by considering the nature of our food. The question of food, however, is treated also in the physiological section of this book. Here, therefore, we need look at the matter only briefly and broadly.

Living matter, whether the living matter of an elephant or a flea, a lobster or a lily, is composed of at least four elements—carbon, hydrogen, oxygen, nitrogen—and if we are to keep our bodies going and in repair we must use these elements for building and energising purposes. It is no use, however, to crunch coal in order to get carbon, or to crunch saltpetre in order to get nitrogen. The elements are utilisable for working and building purposes only if consumed in certain shapes we know as food. These foods always consist either of the living tissues of plants or animals, or of starch, sugar, and fatty matter that is in process of being transformed into the living tissues of plants or animals, and they are used to build up the body and to store up at the same time the potential energy of the food,

The Two Great Groups of Foods. Chemically speaking, the substances we find in foods are divided into two great groups—those which contain carbon, hydrogen, oxygen, nitrogen; and those which contain only carbon, hydrogen, and oxygen. The first class are known as *proteins*, or *nitrogenous substances*, and include lean of meat and white of egg. The second class are known as *non-nitrogenous* substances, and this class again is divided into two sub-classes—*carbohydrates*, in which the hydrogen and oxygen are present in the same proportions as in water; and *fats*, where the hydrogen and oxygen are not in such proportions. Among pure carbohydrate foods we find arrowroot, bananas, sago. Among fats are the fat globules of cream and the fat of animal flesh.

These, then, are the kinds of chemical substances which we use as food; and it is plain that since only the first class contains nitrogen, only the first class suffices in itself to build up tissue into complete living form. Carbohydrates and fats can supply only the carbon, hydrogen, and oxygen required. The nitrogen must be supplied by substances of the first class. It is possible, therefore, to live exclusively on proteins, but, theoretically, not on fats and carbohydrates alone.

Most foods contain two or more of the classes of chemical constituents we have named. Thus bread contains both starch and protein matter, eggs contain both fat and protein matter, meat contains both fat and protein matter, grapes contain both sugar and protein matter.

How Much Energy Foods Provide. Proteins, fats, and carbohydrates are all combustible, and, as we have explained in the previous chapter, the heat formed on their combustion is a measure of the energy they can give to the body in mechanical and thermal shape. We have simply to burn meat and fat and starch in order to discover how much energy they contain. Thus estimated, the energy value of the three classes of food constituents is as follows: 1 gram of protein = 4·1 calories—*i.e.*, on combustion it produces enough heat to raise 1 kilogram of water 4·1° Centigrade; 1 gram of carbohydrate = 4·1 calories—*i.e.*, on combustion it produces enough heat to raise 1 kilogram of water 4·1° Centigrade; 1 gram of fat = 9·3 calories—*i.e.*, on combustion it produces enough heat to raise 1 kilogram of water 9·3° Centigrade.

We could boil more than twice as much water with one pound of butter as with one pound of starch or sugar. The energy value of butter is therefore twice the energy value of proteid.

How Much Food does a Man Require? Now let us consider the question of how much food a man requires to eat in order to maintain the integrity of his tissues and produce the maximum of useful work.

In the first place, how much protein does he need? What does experience say in the matter? How much protein food does the average man require to consume in order to keep up his weight, his warmth, and his work? The average man himself can give us little information, since the average man eats not in order just to keep up his weight and maintain his heat energy. He eats as much for pleasure as for profit, and the amount of protein he eats depends more on the size of his banking account and on the availability of meat than upon the requirements of his brain and body as a working machine.

Experiments were made, however, and the experimenters came to the conclusion that a man doing an average amount of muscular work excretes about twenty grams of nitrogen daily, and excretes more than he takes in unless he consume at least twenty grams of nitrogen daily in the form of protein food. It was apparently proved that nitrogenous equilibrium was maintained only when the income of nitrogen was at this figure or above it.

The Experiments of Chittenden. Twenty grams of nitrogen represent about 125 grams—one pound and a quarter—of lean meat, or about twenty eggs a day, and for long this was thought to be an irreducible minimum. But a few years ago an American scientist, Professor

R. H. Chittenden, made new experiments and proved that the tissues can be built up and energy maintained, at any rate for some little time, on a diet containing only about 56 grams of protein, and this amount may be accepted as an amount of protein sufficient to meet the requirements of the body, for since then other experimenters have succeeded in maintaining nitrogenous equilibrium upon diets containing only 25 to 35 grams of protein.

How Many Calories of Energy Men Produce. Any diet, then, containing 56 to 60 grams of protein will provide all the nitrogen the body requires, but it will not suffice to provide all the heat and the energy that the body generates. Fifty-six grams of protein have a fuel value of about 230 calories ; that is to say, on combustion they would give forth sufficient heat to raise 230 kilograms of water 1° Centigrade. But the body of a fasting man at rest produces daily as work and heat about 2000 calories of energy ; that is to say, enough energy, if all were in the form of heat, to raise 2000 kilograms of water 1° Centigrade. And the body of a man doing moderate work produces daily as work and heat about 3000 calories of energy—enough energy, if all in the form of heat, to raise 3000 kilograms of water 1° Centigrade. And the body of a man doing hard work may generate in one day 9000 calories of energy—enough energy, if all in the form of heat, to raise 9000 kilograms of water 1° Centigrade.

Put more picturesquely, 56 grams of protein have enough fuel value to raise about a pint of water to boiling-point. But a man's body, even at rest, generates enough heat and energy daily to raise about 9 or 10 pints of water to boiling-point, and a man's body at work generates enough heat and energy daily to raise 15 or even 45 pints of water to boiling-point.

A man requires, therefore, for the exercise of ordinary energies, daily food of the fuel value of 3000 calories, and for the exercise of extraordinary energies much more, though Chittenden maintains that on a suitable diet even hard muscular work can be performed on a diet of the fuel value of 3000 calories. In what form, then, is a man to take in his fuel ? We can boil a kettle, and we can also work and heat a man, by burning eggs, or sugar, or oil, or other foods. The white of an egg, a small lump of sugar, and a thimbleful of olive oil will all produce the same amount of heat when burnt, and will therefore be of more or less equal value as sources of bodily heat and energy. In what proportion should we mix proteins, fats, and carbohydrates to get the best result from our fuel ?

Protein we *must* have to the extent of about 60 grams a day, and it might seem best to take *all* our fuel in that form, but that would mean the consumption of about eighty eggs or five pounds of lean beef, and such a diet would be impossible of digestion.

Fat is a very concentrated fuel. Weight for weight, it has twice the fuel value of proteins or carbohydrates, and, provided that we have 60 grams of protein in our diet, a few cupfuls of oil a day would suffice in theory to keep our bodies at work. But fat is not readily burnt in the body ; it is apt to upset the digestion, and it is also apt to accumulate in the tissues.

Carbohydrates, starches, and sugars have not so much fuel value, weight for weight, as fat, but they are somewhat more agreeable to take, and they are certainly much more digestible. Like fat, however, they tend to produce fat in the tissues.

The Necessity for a Mixed Diet. The digestive apparatus of the body, which has special ferments for the digestion of both proteins and fats and carbohydrates, would seem to indicate that all three food substances should be combined in a natural dietary, and practically all authorities are agreed that all three should be represented.

In his book on "Food and Dietetics" Dr. Hutchinson gives the following tables of dietary proportions recommended by various authorities.

AUTHORITY	PROTEIN	FAT	CARBO-HYDRATES	CALORIES
Munk	105	56	500	3022
Wolff	125	35	540	3030
Voit	118	56	500	3055
Rubner	127	52	509	3092
Playfair	119	51	531	3140
Moleschott ..	130	40	550	3160
Atwater	125	125	450	3520
Average ..	121	59	510	3135

The points most at issue at present are how much protein food should be taken, and in what form should it be taken.

Is the Minimum of Protein the Best ? As we have just mentioned, Chittenden proved that the body requires only about 60 grams of protein for its upkeep, but as a result of his experiments he came to the conclusion that the minimum of protein was also the *optimum*, and that men were stronger and more energetic when the protein in their diet was reduced to this minimum required for tissue building, and when all the extra fuel required for energy is taken in the form of fat and carbohydrates. On such a diet he contends a man can do hard muscular work on food of a fuel value of less than 300 calories. He holds that the proteins require to be split up before they are burnt, and that this process of splitting constitutes, in reality, a waste of energy. "Increase in protein food," he says, "may help to make new tissue, but the source of the energy of muscle work is to be found mainly in the breaking down of the non-nitrogenous materials, carbohydrate and fat."

Some of the most interesting of Chittendens' experiments were made with men of the Hospital Corps of the United States Army. They were given on the average 56 grams of protein a day, whereas they had been accustomed to three times that amount in their former food ; and the total fuel value of their food was kept at under 3000 calories per day. Yet the men increased in strength and in power of endurance, and they lost little weight.

The following table taken from Chittenden's "Nutrition of Man" shows some of his results.

RESULTS OF CHITTENDEN'S DIETARY

Total Strength			Total Strength		
—	October	April	—	October	April
Broyles ..	2560	5530	Morris ..	2543	4869
Coffman ..	2835	6269	Oakman ..	3445	5055
Cohn	2210	4002	Sliney ..	3245	5307
Fritz	2504	5178	Steltr ..	2838	4581
Henderson ..	2970	4598	Zooman ..	3070	5457
Loewenthal	2163	5277			

It will be seen that some of the men more than doubled in strength in six months' time.

Sixty grams of protein are contained in half a pound of lean meat, in nine hens' eggs, in half a pound of American pale cheese, in one pound of uncooked macaroni, in one and a third pounds of white wheat bread, in half a pound of dried peas, in ten pounds of bananas, in thirty-three pounds of apples. Half a pound of meat, half a pound of potatoes, half a pound of bread, half a pound of butter, will provide 60 grams of protein and enough fat and carbohydrate to make up 3000 calories of fuel energy. Or we may take all the protein in the form of nine eggs, and add fat and carbohydrate fuel in the form of butterscotch. Or we may take the protein in the form of half a pound of plasmon, and add fuel in the form of bananas.

CHEMICAL COMPOSITION AND FUEL VALUE OF SOME COMMON FOOD MATERIALS

FOOD MATERIALS.	Protein.	Carbohydrates.	Fat.	Water.	Mineral Matter.	Fuel Value.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per lb.
Fresh beef, loin, lean edible portion	24·2	0	3·7	70·8	1·3	615
Cooked beef, roasted	22·3	0	28·6	48·2	1·3	1620
Broiled tender loin steak	23·5	0	20·4	54·8	1·2	1300
Fresh leg of lamb, edible portion	19·2	0	16·5	63·9	1·1	1055
Roast leg of lamb, edible portion	19·4	0	12·7	67·1	0·8	900
Roast leg of mutton, edible portion	25·9	0	22·6	50·0	1·2	1420
Smoked ham, fat edible portion	14·8	0	52·3	27·9	3·7	2485
Roast turkey, edible portion	27·8	0	18·4	52·0	1·2	1295
Fresh cod, dressed	11·1	0	0·2	58·5	0·8	215
Boiled hens' eggs	13·2	0	12·0	73·2	0·8	765
Butter	1·0	0	85·0	11·0	3·0	3605
Whole cows' milk	3·3	5·0	4·0	87·0	0·7	325
Oatmeal	16·1	67·5	7·2	7·3	1·5	1860
Rice	8·0	79·0	0·3	12·3	0·4	1630
Wheat flour, entire wheat	13·8	71·9	1·9	11·4	1·0	1675
Boiled rice	2·8	24·4	0·1	72·5	0·2	525
Brown bread	5·4	47·1	1·8	43·6	2·1	1050
Custard pie	4·2	26·1	6·3	62·4	1·0	830
Green peas	7·7	16·9	0·5	74·6	1·0	465
Boiled potatoes	2·5	20·9	0·1	75·5	1·0	440
Almonds, edible portion	21·0	17·3	54·9	4·8	2·0	3030
Peanuts, edible portion	25·8	24·4	38·6	9·2	2·0	2560
Pine nuts, edible portion	33·9	6·9	49·4	6·4	3·4	2845
Brazil nuts, edible portion	17·0	7·0	66·8	5·3	3 9	3265

The importance of Chittenden's contentions, if they are correct, is that they point a way to increase the energy of a man and at the same time point a way to decrease the cost of his dinner. Protein is expensive; the butcher's bill is always a heavy item in the mess-bill; and if a man can live more healthily and efficiently on a half or a third of the protein to which he has been accustomed, so much the better for rich and poor.

Protein and Extremes of Feeding. Unfortunately, it is doubtful whether Chittenden's meagre diet with a low proportion of protein is really permanently conducive to energy. No doubt many people eat too much food, and especially too much protein, but there seems some reason to doubt whether energy can be permanently retained unimpaired on the small quantity of protein Chittenden advocates. It is true that the men under observation did increase in strength, but this may have been due to regular life and to improved digestion following the cutting off of excess of food. It seems probable, indeed, that they went from one extreme to the other—from overfeeding to underfeeding. Certainly they had a craving for a fuller diet, and all afterwards relapsed and went back to the fleshpots of Egypt. We must remember that protein is the most readily burnt of all the food materials, and that in amounts over and above the requirements of the tissues it goes to make heat, and many of the subjects of Chittenden's experiments suffered intensely from cold.

The Chemical Composition of Foods. So far we have considered the chemical constituents of food—proteins, carbohydrates, and fats. But foods themselves, as we have said, seldom consist of any one kind of chemical substance; they usually consist of two or more of the chemical substances together. Eggs, for instance, contain protein and fat; wheat contains protein, fat, and carbohydrate; potatoes contain protein, starch, and a little fat.

If, then, we are to proportion duly the constituents of our diet, we must consider the chemical composition of the articles we eat. We hear people saying that bananas are very nutritious, but if we tried to live on bananas alone we should have to eat far too much carbohydrate in order to get enough protein. Again, if we tried to live on lean meat alone it would be necessary to eat about five pounds of meat a day. So far as possible, we ought to choose and combine foods so that their constituents may approximate the proportions given by scientific authorities in their model

diets—that is to say, our diet should contain about 120 grams of protein to 60 of fat and 510 of carbohydrate. But there is no doubt that the human constitution is wonderfully adaptable, and that diets may vary qualitatively within pretty wide limits without much detriment to the health, provided there is sufficient protein and a sufficiency of calories. Human instinct, too, is pretty sound. It has taught mankind to combine its foods in much the same way that science suggests. We make up for a deficiency of carbohydrates in our meat by the addition of bread and potatoes; we make up for a deficiency of fat in our bread by spreading it with butter.

The interesting table given above was prepared by Chittenden from data derived from a bulletin of the United States Department of Agriculture.

Digestibility of Foods. It is necessary to consider not only the chemical constituents of food, but also the relative digestibility of various foods. Judging merely by their constituents as shown in the above table, almonds and Brazil nuts ought to be the most nutritious food one could possibly eat. A pound of almonds contains enough protein for tissue building, and enough carbohydrate and fat for the supply of energy, and has a fuel value of over 3000 calories, whereas a pound of rice has a caloric value of only 1630 calories. Yet rice is really the more nutritious of the two, for the nutritious material of the almond is mixed with indigestible cellulose and is only very partially absorbed. Again, beans and peas and lentils contain a considerable amount of protein, and are often compared with meat, but we find that, gram for gram, animal protein is much more completely absorbed than vegetable proteins, and there is also some reason to believe that there are proteins *and* proteins, and that vegetable protein is not of so much value for building purposes as animal protein. Yet again, proteins are better absorbed when given with carbohydrates than when taken by themselves—another argument in favour of a mixed diet.

Still another point has to be considered. We have to consider how much energy the body expends in the digesting of various articles of food. One has to consider not only how much energy the body obtains, but how much energy it expends to obtain it, and we can only find out the profit of the food to the organism by doing a little sum in subtraction.

Pawlow's Interesting Discovery. Professor Pawlow, who obtained a Nobel Prize for his work, showed that "each separate kind of food corresponds to a definite hourly rate of secretion, and calls forth a characteristic alteration of the properties of the juice," and that the protein of bread requires five times more pepsin (the digestive ferment of the stomach) than the protein of milk. He also showed that in the intestine a similar difference obtains, and that bread protein requires more pancreatic ferment than meat protein, and that meat protein requires more pancreatic ferment than milk protein. Accordingly, the energy obtained from the protein of meat is much more cheaply obtained than the energy obtained from the protein of bread, and the energy obtained from the protein of milk is obtained more cheaply still. The expense, then, must always be considered in estimating the value of any food.

A Certain Bulk of Food Desirable. There is an idea prevalent that the smaller in bulk food is in proportion to the nutrition it contains, the less work it means for the digestion, and patent foods in pilule or tablet form seem to many people to be the ideal form of nutriment. This, however, is a great mistake. The digestive organs consist, among other things, of a big muscular bag called the stomach, and of several feet of muscular tubing called the intestines, and they are obviously meant to do muscular work. It is nothing less than an insult to offer such strong muscular organs a few pills and tablets to play with. They are not moved to churn or propel them. Further, secretion and muscular movement are in close nervous association: the movement of the chewing muscles, and no doubt also the movement of the gastric and intestinal movements, promote gastric and intestinal secretions; and if the digestive organs are not stimulated by a certain bulk of food to vigorous movement, then secretion is also deficient, and indigestion and constipation are very likely to result. Many of the cases of indigestion and constipation in small eaters are due largely to the fact that the small bulk of the food taken, and often its soft and absorbent character, fail to stimulate muscular movement and secretion.

Mastication is Desirable and Necessary. Another mistaken idea is the idea that food is most easily digested if it be fluid and sloppy. That is not so. Digestion is initiated in the mouth by the act of mastication, and food is more likely to be well digested if it require mastication before it is swallowed. Mastication mixes the food with the digestive ferment of the saliva, but it also stimulates the flow both of saliva and gastric juice. Further, taste stimulates the secretion of digestive juices, and to masticate the food well is to taste it well, and, indeed, taste is probably given us to ensure thorough mastication. Mastication also reflexly stimulates the heart and improves the circulation, and so indirectly aids digestion, and perhaps the apparently foolish custom of chewing chewing-gum may be indulged in because of this pleasurable physiological consequence.

Some few years ago an American, by name Horace Fletcher, discovered that by well masticating his food he was able to reduce it to a remarkable extent without detriment to his health. Indeed, he found that if he chewed well enough he could live on three eggs, twelve ounces of potatoes, and about two pints of milk with cream a day, and could maintain his weight and energy on this meagre dietary though playing six sets of tennis a day, or riding an hour and a half on horseback with an hour to an hour and a half's walk or climb daily, in addition to much reading and writing. RONALD MACFIE

Auctions and Markets Compared. The Sale Direct to Dealers and Butchers. Proportions of Albuminoids, Carbohydrates, Fats, and Minerals in Foods.

SELLING AND FEEDING LIVE-STOCK

SELLING LIVE-STOCK

The sale of live-stock is much less easy and satisfactory than the sale of corn. With samples in his pockets, the farmer may visit the local corn exchange, or millers and corn merchants, but in the sale of his stock much more labour and judgment are involved. A sample of corn may and should realise its actual value, for its valuation is comparatively simple, but both fat and store cattle, like milking cows, are almost invariably valued on a different basis by different individuals, and, although a price is ultimately arrived at, there is seldom the same satisfaction as a result of a completed transaction. This is owing to various causes, as, for example, the weight of the actual carcase of a fat animal as butcher's meat, its quality, which can seldom be determined with real accuracy while the animal is living, the value of the offal, and the actual market value.

The Cattle Auction. We may assume that there are four methods of selling live-stock—by auction; in the open market or fair; direct to the dealer or the butcher on the farm; and through the medium of advertisement. The auction is usually conducted on market day by an independent auctioneer, who runs the business for his own profit; but in a small number of cases farmers have combined, and run an auction of their own with the co-operation of a paid auctioneer. This plan is generally a good one, and should be extended. The auctioneer has nothing to gain by leaning to the dealer or encouraging rings of dealers and butchers, which he is sometimes obliged to do when working on his own account, in order to secure and retain their patronage, because without the attendance of dealers many auctions would quickly go to the wall. Unless an auction sale is well attended, it is next to useless for farmers to send stock, even though they place reserve prices upon them.

The buyers at the auction are chiefly dealers, butchers, and farmers. The butchers buy for slaughter, the dealers for re-sale to their customers—farmers and butchers alike—or sometimes for the purpose of taking their purchases to other markets where they anticipate realising higher prices. This plan, however, is a matter of speculation, and is justified only by the intelligence and expertness of the dealer. The stock sent to the auction mart chiefly consist of horses, fat cattle, calves, sheep, and pigs, store cattle and store sheep; and here farmers are frequently able to buy breeding stock, or stock for summer grazing or winter feeding, at prices and under conditions which before the establishment of auctions were non-existent.

Open Markets and Fairs. Stock is sold in the open market in almost all market towns, and at the occasional fairs which are held in different parts of the country. It is therefore important to a farmer to be sufficiently near several market towns that he may be able to avoid driving his stock long distances—a practice which involves expense on the one hand and loss of condition on the other. Fat pigs are usually drawn to market—a plan which should be followed as far as possible with fat sheep and calves; but, as a rule, cattle and sheep, whether in store or fat condition, are driven sometimes long distances, with the result that they may arrive empty, perspiring freely, with dusty, ragged coats or fleeces, and altogether unpresentable. In such cases considerable losses may result from a faulty or careless system of management.

To realise their full value, stock sent either to market or auction should be presented in clean and good condition. Abundant time should be allowed for the journey, and, if the animals are allowed to graze and drink on the roadside quietly and leisurely, so much the better for the result. An animal should enter the sale ring—and the remark applies equally to the open market pen—sleek, quiet, contented, and well filled. It is difficult enough to obtain the value of stock under such conditions, but it is impossible to do so when condition has been lost, even though the loss be temporary. Fat stock is frequently sent to the great London and other markets by farmers, who place them in the hands of salesmen, but a salesman acting, as it were, as agent is not always to be relied upon. Where a consignment is important, the farmer should attend the market and see precisely what happens.

Sale of Slaughtered Stock. In some cases fat stock are slaughtered on the farm—this frequently happens to swine—and consigned to salesmen in the meat market, who, upon application, send baskets for the purpose of packing. On application, too, quotations may be obtained as to price, but the farmer will be wise to ignore figures, which the salesman would be himself the first to ignore if it pleased him. On receipt of the account, the price remitted may be less than the quotation, an explanation being given to the effect that the market was bad, or that prices had fallen. Again, however carefully carcases have been weighed—and weighing should never take place until they have cooled—it may be found that the weights as shown by the butcher on his account and those taken on the farm are entirely different, and always in favour of the butcher. For these, among other reasons, it is difficult to recommend the practice of consigning carcases to the wholesale market. In all cases, however, it should be emphatically understood that price depends very largely upon quality and condition.

Where cows are sent into the market they should be of the type demanded by the buyers of the district. Large, big-framed cattle are preferred, of good quality—a great point with many buyers—young, vigorous, healthy, in thoroughly good condition, with large, well-filled udders, showing evidence of milk-producing power, and of such quality of flesh as would be likely to make good butcher's meat when the time arrives for fattening.

Selling Direct to the Butcher. Where a farmer is able to arrange with a dealer or a butcher, he will find this one of the simplest and best methods of disposing of his stock. A neighbouring butcher, who can depend upon being

supplied with a good article, is often willing to pay a better price than other people, and he is worth considering and accommodating if he is willing to buy with regularity. There are, too, many dealers who drive from farm to farm, and who will call and make regular purchases if they are liberally treated. It is at all times worth considering whether attention may not be advantageously given to such men, and frequent expeditions of master and stock to market altogether avoided.

In selling to a butcher, the stock should be sold by weight, and the weighing of the carcases conducted in the presence of the owner, a price per stone having been agreed upon. If, however, the butcher prefers to buy at a fixed price per animal, the farmer should learn to judge value by weight, and in this case a weighbridge becomes essential. Having ascertained the live weight, it becomes necessary to estimate the carcase or dead weight, in accordance with the condition of the animal, whether half fat or fat. Some farmers are excellent judges of weight; others, with confidence in themselves, are bad judges, and frequently lose in consequence of pitting themselves against the much more experienced butcher or dealer.

Pedigree Stock. Where the farmer breeds pedigree stock, or stock of a specially good type intended for reproductive purposes, he may find many customers who will pay him more than market price for what he has to sell through the medium of advertisement. Advertisements should be frequent and explicit, but it is next to useless to adopt this method of selling unless the stock offered is good, and can be shown in fine condition. Intending buyers may be expected to pay visits of inspection, and practically the only incentive to complete a purchase is given when they see before them something which is really attractive, as well as supported with a good pedigree. A really good animal, when young and in fine order, will sell itself. It is folly to keep animals intended for sale when they are at their best.

PRINCIPLES OF FEEDING

Farm animals and their produce are, to a large extent, what they are made by man's ingenuity in the process of selection and feeding. Down the ages through which agriculture has been practised, experience has done much to economise production, but it is probable that more has been accomplished during the past century in the one case, and in the past sixty years in the other, than during all time.

It formerly occupied a large portion of the life of a farmer to acquire by experience sufficient knowledge for his purpose in the matter of feeding, whereas today, owing to the results of scientific investigation, it is possible to master the principles of feeding in a few months, and thus to start with a definite purpose on practically secure grounds.

A growing plant collects from soil and atmosphere materials which it transforms into various compounds, and which, when consumed by animals, are converted into meat, milk, wool, and hair, among material products, and energy, to which reference will presently be made. What, then, are the materials upon which plants draw or feed for these purposes?

Materials on which Plants Feed. Among the chief are carbon (appropriated in the form of carbon dioxide, or carbonic acid), calcium (which combined with oxygen forms lime), potassium, sulphur, phosphorus, sodium, magnesium, and iron. Carbon, which forms the largest proportion among the constituents of plants, has been estimated to be present in the atmosphere in its combined form to the extent of 7¾ tons over every acre of land, while nitrogen, which forms so large a proportion of the atmosphere, and which is the most expensive of the fertilising elements, is directly appropriated by plants of the leguminous order, such as beans, peas, and clover; the property they thus possess practically doubles their value to the farmer.

The growth of crops involves on all old soils, such as those of the British Isles, the application of manure. The principal reason for this is that three of the constituents essential to plant life and growth are, so far as their availability is concerned, removed from the soil so rapidly and so effectually—this fact applies in many cases to lime as well—that, unless they are returned in the form of dung or chemical fertilisers, the soil becomes exhausted and refuses to grow a profitable crop. These materials are nitrogen, phosphoric acid, and potash.

Food for Cattle. Animals are fed upon a great variety of foods. They include the dry fodders—hay and straw—the cereals, the pulses, roots, grasses, and other green crops, and the cakes, chiefly the residue of linseed, cotton-seed, palm-nut, coconut, rape, sesame, soya bean, and others from which the oil has been largely extracted. It is largely owing to the employment of cakes, pulses, and cereals that high feeding is possible, and that the early maturing of stock for the butcher has been so successful in practice.

Maintenance Rations. Food may be supplied to the animal for the purpose of maintenance alone, or for maintenance plus increase in weight, involving the production of meat or milk. In either case it is well to understand the nature of a maintenance ration. Maintenance practically means provision for the maintenance of the natural heat of the body—the expenditure of force and energy and the repair of muscle and other tissue. When we add to the maintenance ration additional food, we provide for the growth of the fœtus in the pregnant animal, for the growth of the young, for the production of meat, and for the manufacture of by-products, such, for instance, as milk and wool.

Owing in part to the difference in the structure of the various animals on the farm, different foods or combinations of food are supplied to stock in accordance with their special requirements. Thus the horse is fed to enable him to draw heavy weights or to travel at high speed, while the dairy cow is fed for the production of milk. And thus it is that knowledge of the composition of foods, their market and manurial value, are so essential to both breeder and feeder. The food of an animal, unlike that of a plant, which is built up by the aid of certain constituents of the atmosphere, a very small proportion of the mineral matter of the soil, and water, must be practically ready-made, and composed of such substances, and in such proportions, as will maintain the normal temperature of its body, provide for the waste of tissue and the expenditure of energy.

The materials present in food which meet these requirements are known as protein, carbohydrates, and fat, and science has determined what quantities of each are necessary in the provision of rations for horses, cattle, sheep, and pigs of given weights. The proportionate supply as between the digestible protein and the digestible carbohydrates—for neither are completely digested—and fats is known as the *albuminoid ratio.*

Protein. Protein is the only food constituent which contains nitrogen; hence it is sometimes described as nitrogenous matter. It includes the albuminoids, the specially nutritious nitrogenous constituent of stock foods, and the amides. The albuminoids undoubtedly provide for the manufacture of all tissues save fat, and they probably contribute to the formation of this also, owing to their richness in carbon (55 per cent.). The albuminoids also assist in the provision of heat and energy. They include the gluten of grain, the legumin of peas, beans, and other plants of the leguminous order, the casein of milk, and the albumin of the egg. The elements of which the albuminoids are composed are carbon, oxygen, hydrogen, nitrogen, sulphur, and sometimes phosphorus. The nitrogen compounds known as *amides* also undergo combustion, and produce heat and energy in the animal body, but there is reason to believe that they exert no influence in the formation of flesh.

Foods rich in albuminoids, like foods rich in oil, are costly; hence the importance of producing them on the farm, and of simultaneously providing for the feeding of the stock and the soil, because where a leguminous crop is grown the soil is enriched by the nitrogen in its roots. Although the albuminoids are rich in carbon, it would be folly on account of their cost to employ them as food fuel, for the carbon of food undergoes combustion in the animal body as certainly as the carbon of coal in the furnace. The coarser foods of the farm—hay, straw, and roots in particular—which are rich in carbohydrates, consequently provide carbon at a much smaller cost.

Carbohydrates. Carbohydrates, the chief of which are starch and sugar, are composed of the elements carbon, hydrogen, and oxygen. They are sometimes described as heat-giving or carbonaceous foods, a term which, as we have seen, may be equally applied to albuminoids and the fats. The carbohydrates, however, are more than heat-givers, for they are the principal source of energy, and it is chiefly for this reason that they are provided in stock rations in much larger quantities than either the albuminoids or the fats. Starch and sugar, like cellulose, the material of which the cell-walls and fibrous matter of plants are chiefly composed, are abundant in all classes of food, and are for the most part highly digestible. They are believed to be chiefly responsible for the production of fat.

Fats and Oils. The fats and oils produce upon combustion some 2·29 times as much heat as the carbohydrates, sugar and starch, because they contain a much larger percentage of carbon, but, unlike starch, they form a portion of the animal body, and possibly are in part deposited as animal fat without undergoing any marked change. The fat of food, in addition to its property of providing heat, energy, and animal fat, is a valuable digestive, and a ready means not only of increasing weight but of contributing to the appearance and condition of stock of all kinds. It assists, too, in preventing a waste of the albuminoids, for in the absence of a sufficiency of carbohydrates the animal would draw upon the carbon and hydrogen of the albuminoid matter it consumed.

Mineral Food. Reference has been made to the mineral constituents of plants. These are essential to the animal, inasmuch as they provide for the construction of the bones and the manufacture of the digestive juices, the former containing

RELATIVE VALUES OF CATTLE FOODS

Foods	Water	Digestible		
		Albuminoids	Carbohydrates	Fats
NITROGENOUS DRY FOODS				
Linseed cake	12·2	24·8	27·5	8·9
Decorticated cotton-cake	11·2	31·0	18·3	12·0
Common cotton-cake	11·3	17·5	14·9	5·5
Palmnut cake ..	10·5	16·1	55·4	9·5
Rape cake	11·3	25·3	23·8	7·7
Cocoanut cake ..	9·4	18·2	47·4	11·2
Sunflower cake ..	10·3	31·3	24·7	7·6
Sesame cake ..	11·5	28·0	16·1	10·4
Beans	14·5	23·0	50·2	1·4
Peas	14·3	20·2	54·4	1·7
Lentils	16·5	21·4	46·0	2·2
Wheat bran (coarse) ..	12·9	12·6	42·7	2·6
Malt combs	10·1	19·4	45·0	1·7
Brewers' grains ..	76·6	3·9	10·8	0·8
Desiccated grains ..	12·0	19·1	42·0	8·5
Shorts, or middlings	12·5	10·8	44·8	2·8
NITROGENOUS GREEN FOODS				
Red clover (in full flower)	80·4	1·7	8·7	0·4
White clover (in full flower)	80·5	2·2	7·9	0·5
Alsike clover (in full flower)	82·0	1·8	6·9	0·3
Lucerne (in flower)	74·0	3·2	9·1	0·3
Sainfoin	81·4	3·0	7·9	0·5
Crimson clover ..	81·5	1·5	7·5	0·3
Vetches	82·0	2·5	6·7	0·3
Peas	81·5	2·2	7·4	0·3
Rape	87·5	2·0	4·8	0·4
DRY FODDER				
Lucerne (good) ..	16·5	12·3	31·4	1·0
Sainfoin	16·7	7·6	35·8	1·4
Vetch hay (medium)	16·7	9·4	32·5	1·5
Red clover (medium)	16·5	10·7	37·6	2·1
CARBONACEOUS DRY FOODS				
Wheat	14·4	11·7	64·3	1·2
Barley	14·3	8·0	58·9	1·7
Oats	14·3	9·0	43·3	4·7
Maize	14·4	8·4	60·6	4·8
Malt	7·5	7·5	62·8	1·6
Ricemeal (good) ..	11·5	11·2	52·9	13·9
Maize germ-meal ..	11·9	10·5	44·0	14·8
Buckwheat . ..	14·0	6·8	47·0	1·2
Rye	14·3	9·9	65·4	1·6
Meadow hay (poor) ..	14·3	3·4	34·9	0·5
Meadow hay (good) ..	15·0	7·4	41·7	1·3
Rye hay (good) ..	14·3	6·6	44·3	1·3
Perennial ryegrass (good)	14·3	5·1	35·3	0·8
Wheat straw ..	14·3	0·8	35·6	0·4
Rye straw	14·3	0·8	36·5	0·4
Barley straw (summer)	14·3	1·3	40·6	0·5
Oat straw	14·3	1·4	40·1	0·7
Vetch straw	16·0	3·4	31·9	0·5
Pea haulm	16·0	2·9	33·4	0·5
Bean straw . ..	16·0	5·0	35·2	0·5
CARBONACEOUS GREEN AND OTHER SUCCULENT FOODS				
Potatoes	75·0	2·1	21·8	0·2
Mangels	88·0	1·1	10·0	0·1
Carrots	85·0	1·4	12·5	0·2
Turnips	92.0	1·1	6·1	0·1
Swedes	87·0	1·3	6·3	0·1
Parsnips	88·3	1·6	11·2	0·2
Green maize . ..	82·2	0·7	8·4	0·3
Cabbage	89·0	1·1	6·0	0·2
Kohl Rabi	85·0	2·0	7·7	0·4
Pasture grass (average)	80·0	2·5	9·9	0·4

phosphoric acid and lime, and the latter soda and chlorine. The milk of the cow, too, is rich in the mineral matter necessary in the building up of the young animal.

Foods are not all digested. Portions of each constituent pass through the system unappropriated, and it is therefore essential to know, not only the names of the most economical and essential foods, but the proportions of each of their constituents which are digestible and nutritious.

The tables on page 2748, which include the chief stock foods arranged in their several divisions, show the approximate percentages of water, digestible albuminoids, carbohydrates, and fats.

Chief Stock Foods Analysed. The foods rich in oil or fat are linseed (35 per cent.), cotton-seed (27·3 per cent.), palm-nut (48 per cent.), linseed cake, cotton-seed cake, coconut cake, maize-germ meal, rice meal, palm-nut cake. Foods rich in ash, or mineral matter, vary from 0·7 per cent. in roots to 10 per cent. in rice meal, and 7 per cent. in rye grass, clover, good meadow hay, and vetch hay, the straws and chaff of which and the leading cakes, are all very rich in the same materials. The figures which are supplied here at once indicate which foods are the most concentrated and the most valuable.

If we add together the percentages of albuminoids, carbohydrates, and fat, we are enabled still further to ascertain which foods provide the largest amount of nutritive matter, and therefore, guided by market prices, which in most cases are the most economical. For instance, if we desire to choose between maize and oats, not being tied by any consideration for the provision of albuminoids, we find that while maize contains 73·8 per cent. of digestible nutritious matter, oats only contain 57 per cent. Thus, supposing both foods cost the same sum—say, 2s. 6d. per bushel—the maize weighing 60 lb. per bushel supplies 44¼ lb. of nutritive matter, while oats weighing only 40 lb. in a good sample—38 lb. being more common—provide only 22¾ lb. of nutritious matter, or almost precisely one-half. In such a case the food in the oats would cost double as much as the food in the maize, as we have fully explained elsewhere.

We have always, however, to consider the importance of the albuminoids where they are not provided in the fodder of the farm, and still further—to take an important example—in feeding a horse we have to remember that owing not only to its higher percentage in albuminoids, but to the presence of a larger quantity of husk and its consequently greater safety, the oat possesses a mechanical value which adds something to its economic worth.

Relative Values of Foods. In purchasing a food, it is sometimes useful to estimate its relative value as compared with other foods by the adoption of a system which, making allowance for the fluctuations of market prices, is a help to the buyer; we refer to what is known as *unit value*, which, however, is more commonly applied to the purchase of artificial manures. A unit of albuminoids has been estimated to be worth 2s., of carbohydrates 1s., and of fat 2s. 6d. Thus, supposing we take maize to illustrate our case, we find from the figures in the table that this cereal contains, roundly, 8·4 per cent. or units of albuminoids, which at 2s. is 16s. 9d.; 4·8 per cent. or units of fat, which at 2s. 6d. amounts to 12s., and 60½ units (60·6 per cent.) of carbohydrates at 1s., or £3 0s. 6d., giving a total of £4 9s. 3d. One ton or 4⅔ quarters of maize at 20s. would equal £4 12s. 6d. Taking a series of years, 20s. is about the average cost of maize purchased wholesale, so that at this price a ton, the quantity with which we are dealing in the calculation, would cost but little more than the valuation. If similar calculations are made as applicable to other foods, wider differences may appear, but it is always important to add the manurial value of the food on the basis of the estimated proportions of the nitrogen, phosphoric acid, and potash obtained from it. [See page 308.]

Compound Foods. In purchasing compound foods, such as cakes and meals, it is important that the buyer, guided by the Fertilising and Feeding Stuffs Act, which was passed for his special protection, should submit a sample to the public analyst, appointed for the purpose, for analysis. He will, under defined conditions obtainable from the Board of Agriculture, or from the Act itself, be required to send a duplicate sample to the vendor, together with notice of his intention, and if, as should have been the case, he obtains a guarantee of purity or quality, he will be in a position to obtain compensation should the article he purchases not correspond with the analysis. Although the best makers and merchants may be trusted, there are so many cases of deliberate fraud that no exceptions should be made in this matter, especially as every County Council retains an analyst who conducts the work at a nominal fee. The loss sustained by a purchaser of an inferior or adulterated food is not confined to the difference in market value, for if purchased in large quantities his stock may suffer to an extent which may not be readily understood. Analysis is not arbitrary so far as regards the percentages of food constituents, inasmuch as samples differ, although in a minor degree, and this applies not only to manufactured or compound foods, such as cakes and meal, but to grain, hay, roots, and practically every crop that grows.

Digestibility of Different Foods. One of the most important features in dealing with such figures as most tables of analysis supply is to remember that it is the digestible constituents, and not the total constituents or dry matter of food, which are of importance. Young grass is much more digestible than older grass; finely cut, crushed, ground, or steamed food than whole, raw, or coarse food; and slightly fermented mixtures of roots, chaff, grains, meal, and cake than the same foods fresh and cold. The digestive juices are able to act with greater thoroughness upon food composed of fine particles than upon that which is coarse; and while individuality accounts for much, it is certain that rations given in small quantities, and carefully and finely prepared, are followed by the best results. Again, owing to the difference in the structure of the digestive organs of cattle and sheep, as compared with those of horses and pigs, the two former require bulkier foods and a larger proportion of fibrous matter

It has already been pointed out that foods differ in their digestibility; and, further, that the digestive powers of different animals also vary; and that the cereals and young plants are more perfectly digested than dried fodders, such as hay and straw. The carbohydrates, starch and sugar, are practically all digested, although the starches of different plants vary in the time occupied in their digestion. Again, there is a difference in the digestibility of fats and oils; and although little is known which can be regarded as exact, it is believed that their ab-

sorption in the system of the animal is fairly complete. Something depends, too, upon the aroma of food and its flavour. If it is agreeable to the animal and is relished, the glands are stimulated, with the result that a marked influence is exerted on the digestive apparatus. Again, the larger the ration, the more slowly is it digested.

The Carcase. Let us now mention a few facts in relation to the carcase of the animal. In feeding for the butcher there is a percentage decrease of water, nitrogenous matter and minerals, with an increase of fat. Thus, owing to the diminution of the water percentage, a larger amount of food is produced in the carcase, although in the case of really fat stock this means considerable waste; for while the purchaser of a joint pays for the extra fat, he seldom consumes it. In a half-fat animal, the dry matter of the carcase is about equal to its water contents.

Comparing the fat beast with the lean beast, there is a smaller proportion of the fertilising constituents of food, nitrogen, phosphoric acid, and lime in the former than in the latter. Thus, when fat stock are sold off the farm there is relatively less fertility carried away than when the animals sold are in store condition. Again, although the loss of the mineral fertilisers present in the carcase of a beast is in the gross really small in quantity, weight for weight, cattle sold off the farm take with them more than sheep, and sheep more than swine. The fertilising matter removed in milk and the crops of the farm—grain, pulse, hay, and the like—is much larger in quantity than that removed in fat stock, so that the feeder who consumes his own crops loses very little fertility.

The cost of feeding Irish store cattle, which are so largely purchased by English farmers for fattening for the butcher, has been estimated to reach £17 at 2½ years old, while in Scotland the cost at 20 months is estimated at £18 12s., including insurance, interest on capital, attendance, and grazing.

The Albuminoid Ratio. The albuminoid ratio may be regarded as the proportion of digestible nitrogenous matter present in a food as compared with the carbohydrates and the fats estimated as carbohydrates. The opinions of experts differ to some slight extent as to the figures of the ratio, but we may take it that the ration supplied to the animals of the farm shall consist of one part of digestible albuminoids to from five to six parts of carbohydrates and fat, the fat being estimated as a carbohydrate by multiplying its percentage by 2·29, this being its relative heat and energy producing capacity.

Let us illustrate our case by an example. A man taking average exercise requires about 4500 grains (say, 10 oz.) of carbon and 300 grains (about ¾ oz.) of nitrogen daily as a maintenance ration. Suppose the food he consumes consists solely of bread, he would require 4 lb. daily in order to obtain the necessary nitrogen; but as 4 lb. of bread contains nearly 20 oz. of carbon, this system of maintenance would result in waste. Thus it is that a food like bread, which is rich in carbon, is eaten in conjunction with other foods taken in smaller quantities, such as meat, fish, or cheese, which are rich in nitrogen. Taking a number of authorities collectively, we find that, on the basis of their investigations, an average man doing a moderate amount of muscular exercise requires 120 grams of protein, 500 grams of carbohydrates, and 50 to 60 grams of fat. Here, then, we get a ratio of 1 to 5·5. We remember an instance of a small farmer who fed a few cows solely upon mangels, which, apart from the unsuitability of their bulk, are extremely poor in albuminoids; but supposing the whole of the albuminoids in the mangel to be all digestible and nutritious—which is not the case—a cow of 1000 lb. weight would have to consume nearly 250 lb. of the roots in order to enable her to obtain a sufficient quantity of nitrogen to meet her maintenance requirements alone. If, however, she were able to consume this quantity and to digest it, she would obtain 25 lb. of digestible carbohydrates, or about twice the quantity required in a mere maintenance ration.

The Value of Grass. Let us now take an example in order to show how the abuminoid ratio is calculated. Grass, which, when good, is admirably balanced as a food for cows, will serve as an excellent example; it contains 2·5 per cent. of digestible albuminoids, 10 per cent. of carbohydrates, and 0·5 per cent. of fat. The fat is multiplied by 2·29, as we have shown. The result thus obtained is added to the carbohydrates and divided by the percentage of albuminoids. Thus:

$$\frac{10{\cdot}0 + (0{\cdot}5 \times 2{\cdot}29)}{2{\cdot}5} = 4{\cdot}458$$

so that the albuminoid ratio of *good* grass is 4·458, practically as 1 is to 4½; so rich is it, indeed, that grass of high quality may therefore be regarded as a nitrogenous food.

Food for a Cow. It has been laid down, on the basis of many investigations, especially in Germany and the United States, that a cow weighing 1000 lb. requires for the maintenance of her carcase and the provision of heat and energy 15·4 lb. of digestible nutritious dry matter, which, in terms of ordinary farm rations, is practically equivalent to 24 lb. of the organic matter of her daily food supply. Some investigators, however, slightly increase the quantity of dry matter. The figures referred to (15·4 lb.) should provide some 2½ lb. of digestible albuminoids, 12½ lb. of carbohydrates, and 0·4 lb. of fat, so that the albuminoid ratio would be as 1 is to 5·4.

In the practice of the farm, rations frequently contain a larger proportion of the carbohydrates, especially where large quantities of straw, roots, and maize are used; while in other cases, especially during the summer season, when clover, vetches, and rich grasses are provided, the proportion of albuminoids may be very distinctly raised. The wisest plan, however, is, by the adoption of the system of recording the weights and varieties of food supplied and the milk produced, to ascertain which foods are the most economical. So far, reference has been made to the provision of food for the maintenance of a cow. When she is in milk, however, she requires, in round numbers, an additional pound of digestible dry matter for every gallon she produces.

Scientific Feeding. Much, however, as investigation and experiment have accomplished, we should regard these figures as merely indicative of what science has so far been able to teach us; and the farmer who, while adopting the principle, experiments for himself may possibly find that he obtains more economical results, especially when he produces his own foodstuffs, by the provision of slightly larger quantities of the carbonaceous foods on the one hand or of the nitrogenous foods on the other. Where it becomes essential to purchase foods which are rich in nitrogen, they should be used sparingly, on account of their higher cost, for they are only required for their nitrogenous constituents.

JAMES LONG

The Death-Bed of the Atom. The Wonderful Power It Gives Off in Dying. Can We Use It? Will the Immeasurable Energies of the Atom Transform Society?

THE ATOM'S WONDERFUL SECRET

THE reader is besought not to imagine that the overwhelming and all-embracing significance of the corpuscular theory of matter has been completely indicated, but we may fairly take stock of our theory at this point, and notice how it accords with the statements which we made in leading up to and introducing it. We insisted upon the ultimate inseparableness of physics and chemistry, while pointing out that the physicist is mainly concerned with energy, and the chemist with energy only or mainly in the form which he calls chemical energy. We observed that the difficulties of chemistry are approaching solution at the hands of what is called physical chemistry, and we insisted upon the doctrine of the conservation of energy, which, if it is really true, must necessarily be true in every chemical action.

What Have We Found? In the first place we have found that physics and chemistry are so much one that it is now almost ridiculous to speak of chemical energy. Chemical energy is electrical energy. In the second place, we have found that the magnificent work of two chemists, Dalton and Mendeléef, has been crowned, and the greater part of the immediate problem of chemistry solved, by the labours of a worker who is not a chemist at all, but a physicist. As for the law of the conservation of energy, we cannot yet point out its relations to the theory of Thomson, but we need only remind ourselves of what was lately said about negative electrons shot out from the atom of radium in order to see that the law of the conservation of *matter* requires revision. Now, this law must apparently be regarded as a particular expression of the law of the conservation of energy. And if it be not true, what are we to say of the law which includes it and of which it constitutes a part? And how can we possibly assert it to be true in the same breath as that which serves to say that negative electrons are shot out from unstable atoms such as that of radium, and go—whither? Do they disappear, are they annihilated, are they resolved into ether, the "mother of matter," or are they conserved as such?

Unstable Atoms. We are already in a position to understand that, in speaking of atoms, the terms *stable* and *unstable* are relative. The perfectly stable atom would, of course, be eternal, whereas the perfectly unstable atom would have no period of existence as an atom at all. Remembering this, however, we have to recognise that different types of atoms do vary enormously in their degree of stability, and it is obviously incumbent upon the new theory of matter to explain these differences if it can. It is impossible to discuss this subject, at the present time, in any complete way. Since the greater part of the world of physicists and chemists is working at this subject, new and important facts are being discovered almost as rapidly as the old ones are being set down in print. Nevertheless, some provisional statement is possible.

Atoms Within Atoms. Our previous discussion of the corpuscular theory of matter has enabled us to understand, as twenty years ago not the greatest of living chemists could have understood, a large number of the great facts of chemistry. What amplification does it need in order to enable us to understand the extraordinary fact, discovered by Sir William Ramsay, that small atoms may be born from large ones?

One most important fact has been demonstrated by Sir Joseph Thomson. He shows that it is possible to substitute a system of corpuscles for one corpuscle in certain of the theoretical figures we have described. Thus, three corpuscles arranged in the triangular fashion already figured may exist within an atom and act as a whole, just as one corpuscle would act.

Evidently, this is most important, for it at once gives us some inkling of the manner in which such a small atom as that of helium may spring, practically ready-made, from an atom of radium.

Movement of Electrons. Sir J. J. Thomson has also shown that important facts may be deduced from the movement of the electrons. In a paragraph in a previous section we commented briefly on the movement of the electrons in the atom and showed that the difficulties which it appears to introduce are not serious, but now we may amplify the statement and say that the movement of the electrons actually helps us in our attempt to explain the existence of unstable atoms. Let us take, for instance, the case of five Mayer magnets. It is found that there are two ways in which these may arrange themselves, sometimes as a pentagon and sometimes as a square with one corpuscle in the middle. Now, Sir J. J. Thomson has shown how the possibility of these two arrangements may be explained in the case of the very simple atom which we are imagining for purposes of study. When the electrons in such an atom are moving very rapidly the arrangement will be that of the square with one corpuscle in the centre, but, if their energy of movement is reduced, another arrangement becomes necessary, *and suddenly so*. There must be a certain *critical point*, above which one arrangement is necessary, while below it another is necessary.

The Death-Bed of an Atom. If we conceive of an atom, parts of which are in movement, we have to ask whether any energy

is being lost; there is a most extraordinary and significant parallel between this question and the questions as to the stability of the Solar System or of Saturn and his rings. We may note, by the way, that a Japanese physicist has made an interesting contribution to the theory of the radio-active atom by means of considerations derived from the study of the rings of Saturn. Large and small mean nothing in science.

Now, we have to believe that every atom is slowly losing its energy, this being the fundamental reason why it is *mortal.* Sir Joseph Thomson has written of the "death-bed of atoms," and pointed out that it is at the moment of death, so to speak, that the radium atom gives off the energy for which it is so famous. For ages it has slowly been losing its energy, and at last the point comes which we have called critical. An entirely new arrangement is necessary if the atom is to persist in any shape or form, and this involves the great reduction of the potential energy within the atom and the giving forth of a quantity of kinetic energy proportionate to that reduction. "The only tax the radium atom has to pay," says Sir Joseph, "is the death duty." The amount of kinetic energy which is evolved at the death-bed of the radium atom—after its long life, according to several estimates, of 1200 years—is so great as to suffice abundantly for shooting out from the atom a certain number of its parts. We have only to suppose that among its parts are little systems of corpuscles, which are nowadays going by the name of *sub-atoms*, and which, if they could get free, are none other than atoms of helium.

A Key to a Mystery. We have already seen that the existence of such systems is quite possible, each of them being equivalent, in the structure of the atom, to one corpuscle, and acting as such. The so-called Alpha rays of radium consist, it is believed, of such sub-atoms, which are really equivalent to atoms of helium. These do not, indeed, consist of three corpuscles, as in the case of the sub-atomic system of the imaginary atom we have discussed, but perhaps of about 2000 corpuscles (compare the atomic weight of helium and that of hydrogen).

Such an explanation as we have given is of the greatest value, in that it serves to explain what otherwise seems unintelligible. Why, we might ask, should an atom actually persist for twelve hundred years unchanged and then suddenly break down of its own accord? But now we have a key to this. We see that atoms do not persist unchanged; during all this period the atom, indeed, retains its form and structure, but it is slowly radiating energy. At last there comes the critical point at which the old arrangement is no longer stable—and then comes the crash. The reader will readily be able to supply analogies from his own experience. Why, it might be asked, should a man live at ease and in luxury for years, and then, all of a sudden, be thrown out of the society in which he lives and become a bankrupt and a pauper? The answer is that, though his circumstances have apparently not been changing, he has been living on his capital, radiating his potential energy, and at last a critical point is reached, and then comes the crash.

And now we are the better able to understand what we described on page 1892 as the "emanation" of radium. We saw that this element yields a gas, or emanation, which is not gaseous radium. We saw also that Sir William Ramsay has discovered that when the spectrum of this emanation is examined after an interval of four weeks or less the spectrum of helium is recognised. But lately we have passed beyond the simple view that the emanation of radium consists of a multitude of immature and unrecognisable helium atoms. That was hardly credible at any time. What, then, can we provisionally regard as the exact relation between the helium produced by radium and the emanation which it also produces?

The Emanation of Radium. It seems that the emanation itself consists of atoms which are of very large size indeed; not as large as the radium atom, however, though they belong to the same type. For the time being we may, perhaps, conceive—possibly in more simple terms than may ultimately be shown to be justified—that when the radium atom reaches its critical point it breaks up into one or a number of Alpha particles or helium atoms on the one hand, and one of these large emanation atoms on the other. These repeat, though with very great speed, the history of the original atom. Before long they break up, yielding more Alpha particles or helium atoms, and a second type of emanation, which has been called emanation X. This again breaks down in its turn after a short time. There are in all probably five stages, as we have already seen, and we have already noted that the final atom—or, rather, the atom which is final for a time—seems to be that of lead. As for the first emanation, and the assertion that it consists of definite atoms of an absolutely distinctive and specific kind, we may note that Sir William Ramsay proposes to call it *ex-radio*—in order to indicate that this is an *element derived from radium.*

We have spoken of these various stages, but the reader must not imagine that there is any equivalence of time between them. The radium emanation undergoes its change in a matter of days. Emanation X takes only a few minutes; the next two stages not many minutes more, but the last stage, of which lead, perhaps, is the final product, is estimated to take centuries.

The Internal Energy of Radium. And now we are also in a position to add somewhat to our previous remarks concerning the energy of radium. We accept, of course, the disintegration theory, having been able to exclude the previous theories advanced by Sir William Crookes and by Lord Kelvin. The reader will scarcely need us to insist that when we discuss radium we are discussing principles which are true of atoms generally. On a previous page it was said that "the external energies of radium can be manifested only at the cost of its internal

energies . . . it is only in virtue of the disintegration of its atoms that radium has been able to exercise its remarkable properties." There is not much need to insist again upon the enormous measure of the energy which is liberated by the disintegration of such a large atom as that of radium. Sir Joseph Thomson has quite recently made an important criticism upon the often-repeated statement that, say, half a pound of radium would drive a steamer across the Atlantic.

So it would, if it were possible to obtain half a pound of radium in one mass, but it would take an extremely long time to do so; and for this reason we have to conceive of the energy given out by radium as due to the breaking up of its atoms, *one after another*, as their internal arrangements reach the critical point. It is only on its death-bed, to vary the metaphor, that the radium atom parts with its fortune or power to any appreciable degree. The heat evolved by radium—or, rather, by the breaking up of such atoms in a mass of radium as may happen to break up during the period under observation—is believed to be mainly due to the Alpha particles. The heat is evolved partly by the impact of these particles upon the rest of the radium, and partly by their impact with surrounding objects. These Alpha particles are thrown out from the emanation in all its successive stages. It has been calculated that about three-fourths of the heat produced by radium is thus due to its emanation, in virtue of the Alpha particles which are produced.

The Power of a Thimbleful of Radium. We may quote from Professor R. K. Duncan, who has admirably arranged many of these remarkable facts in his volume "The New Knowledge." Professor Duncan says, on this point: "The volume of the emanation is infinitesimally small. From one gramme of radium compound the volume of the emanation evolved would not amount to more than 1·3 of a cubic millimetre. This needle-point of gas evolves enough heat per hour to raise the temperature of 75 grammes of water one degree. If it were possible to obtain one cubic centimetre—a thimbleful—of this emanation in the form of a gas, we should find that it possessed the power of emitting, altogether, over 7,000,000 calories of heat. This is more than sufficient to raise 15,000 pounds of water one degree, and all this heat from a thimbleful of an invisible gas! The important phase of this statement is that it is altogether outside of any hypothesis or theory. It is a simple, straightforward fact. Now, the heat evolved by exploding the same volume of hydrogen and oxygen mixed in the proportions required to form water is about two calories. We find, then, that the heat evolved by the radium emanation is over 3,500,000 times greater than that let loose by any known chemical reaction."

An Amazing Waste of Power. So much for the amazing measure of the energy which is involved in the structure of atoms. We may turn also to the smallest atom we know—that of hydrogen—the atom which contains much less energy than any other, and quote the estimate of Sir Joseph Thomson that "a gramme of hydrogen has within it energy sufficient to lift 1,000,000 tons through a height considerably exceeding 100 yards." In short, of all the energies which we know in Nature, those which we have long recognised, those extra- or inter-atomic energies which are constantly utilised in order to do the work of the world, are as nothing, are utterly insignificant and negligible, compared with the *intra-atomic energy*—the energy which is within the atoms of matter, of which hitherto no use whatever has been made by man.

But before we pass on to consider, at some little length, the nature of the units of which atoms are composed, we may note briefly another consideration. As we all know, time was when society was based upon militarism, whereas today it is tending to become industrial. The military type of society is the oldest and, of course, the lowest. We have not yet reached the stage when society has become perfectly free from militarism, but everyone who thinks about man and his future looks forward to the day when society will have become completely industrialised and when war, barbarous and stupid as it is, will have ceased for ever.

The Transformation of Society. But there are a few thinkers here and there who are inclined to question the common view that the industrial state of society is the best that can be conceived. At present, as for many ages past, we are engaged in an incessant strife with Nature, and the balance of power is at last coming to lie with "man's unconquerable mind." This is so because we are learning how to utilise natural powers. Nevertheless, an enormous proportion of all mankind are engaged, at one level or another, as "hewers of wood and drawers of water."

This is as good as to say that our conquest of Nature is yet far from complete. But, if we are to judge by the past, we may believe that in time to come society will be no longer industrial, for the reason that industry, as we at present conceive it, will not be necessary. The fact of what are called "labour-saving devices" is one of the most important facts in the whole study of man. Even if we utilised to the full all the ordinary chemical energy which we employ in our furnaces, for instance, there would be a vast economy of labour. The time will unquestionably come when the work of the world, in nearly its whole extent, will be done, not by half-clad men digging coals out of mines or puddling iron, but by the simple pressing of a button. Society will have to pass through stages comparable to those represented by the introduction of the various mechanical inventions which have replaced, let us say, the old spinning-loom.

The Immeasurable Energies of the Atom. It will seem, and unless we are more humane in the future than in the past it will indeed be, cruel to throw countless persons out of work by the introduction of new methods. But what are we to say if we remember the

existence of the immeasurable and inexhaustible energies which lie within the atom—the atom which our very fathers thought to be dead and inert? In a small book, which is now out of print, the writer ventured to call the future social type the *spiritual*, as distinguished from the *militant* and the *industrial*. In so far as any forces other than spiritual forces can hasten the coming of this social type of the future, such forces are undoubtedly to be sought chiefly in the almost unimaginable transformation of all the material conditions of human life which will be achieved—which may, indeed, be made possible at any moment—by the discovery of some means of "tapping" the intra-atomic energies. Were this done, there would be practically no longer any necessity for any of those labours of man which depend upon his need for turning to his own advantage the forces of Nature. Let the reader ask what proportion of human work ultimately comes under this head, and then let him consider how human life must be transformed if such work be rendered unnecessary. In the first edition of this work, published eight years ago, the foregoing paragraph appeared. Its central idea is now being used as the *motif* of a romance, "The World Set Free," by a well-known novelist.

The Power of Every Breath we Draw. We have already referred to some of the uses of radium, but all that we have said is simply as nothing compared with the uses to which radium—and, indeed, all atoms whatsoever—may be put if we are able to harness them. There is nothing inherently impossible in the attempt. It is not a case of making a perpetual-motion machine, nor of getting work under conditions which, according to the second law of thermodynamics [see PHYSICS], are incapable of yielding work. One thoughtful student has suggested, and he is probably right, that the processes of intra-atomic change, unlike the processes of inter-atomic combination and dissociation, are irreversible. It would almost appear as if there were a precise parallelism between the laws of *heat and work* and the laws of *intra-atomic energy and work*. If this be so, we shall never be able to build up a radium atom from smaller atoms, except by somehow putting back into these smaller atoms all the tremendous energies which were dissipated when they were born. Instead of having work done by this process, we should have to do an enormous amount of work in order to accomplish it.

But, on the other hand, there is no reason at all why we should not utilise the energies evolved in the breaking down of large atoms into small ones. The problem, indeed, is not so much how to utilise the intra-atomic energies as how to hasten their normal evolution. Our half-pound of radium would drive the liner across the Atlantic, but it might take ages and ages to do so, simply because a sufficient number of the radium atoms would not liberate their stored-up energies within a reasonable time. The question, then, is how to hasten the normal rate at which atoms disintegrate. In many parts of the world inquirers are now attacking this problem.

"Blowing Atoms to Bits." A few years ago, for instance, the present writer witnessed certain experiments in the Cavendish Laboratory with the Röntgen rays, the object of which was to "blow atoms to bits," if possible, and utilise the energies liberated by the explosion. That is a metaphorical manner of speech, but it is extraordinarily near the literal truth. We may fairly say that in practical physics at the present moment—or in practical chemistry (it does not matter which one says)—the most interesting and important inquiry is *how to blow atoms to bits*, thereby obtaining from them far more energy than one puts into them, just as a little match may make the beginnings of a very big blaze. After all, it is the old problem of transforming potential into kinetic energy, in a new dress. In setting a light to gunpowder so as to send off a cannon-ball, we are transforming into kinetic energy the potential energy contained and locked up *between* the atoms and *in* the molecules of the gunpowder and the oxygen of the atmosphere. Similarly, in attempting to blow atoms to bits by Röntgen rays, or other means, we are seeking to transform into kinetic, or utilisable, energy the potential energy which, as we have already seen, is contained, and contained to an almost incredible degree, *within* the atoms. In his recent Romanes lecture, delivered in June, 1914, Sir Joseph Thomson said that he had still been unable to "blow atoms to bits."

Sir Joseph Thomson's Provisional Conclusions. We quote or paraphrase the following from Sir Joseph Thomson's statement, made on a previous occasion, of his results.

In one hour one gramme of radium will give out sufficient heat to raise a gramme of water from freezing-point to boiling-point. On the average, a radium atom lives for more than 1000 years, and it is only at the expiration of this period, when the atom becomes unstable, that its energy is liberated. This is a long period, even by our scale of reckoning, in which we take the rotation of the earth as the unit of time. If an atom of radium had an inhabitant, he would reckon on quite a different scale of time. Doubtless his unit would be the period of rotation of one of the corpuscles or systems of corpuscles in the atom, and it would correspond to a small fraction of the billionth—that is, the million millionth—part of a second. The life of a radium atom—say, 1200 years—might well appear, therefore, as an eternity to one of its inhabitants, thus raising the question "How is it that the radium atom, after existing for what—relatively to the rhythm of its own processes—is practically an infinity of time, at last collapses and suffers this extraordinary change which results in the giving off of energy?" This change is due to the loss of energy in the corpuscles and systems of corpuscles which rotate in the atom. The atom thus loses its state of moving equilibrium, as a top falls when the speed of its rotation is insufficient to preserve *its* moving equilibrium.

Can we Harness the Atom? Thus the energy of radium is displayed only at the death-bed of the radium atom. During its

lifetime radium is a perfectly conventional element, so far as we know; it is only when it is ceasing to be radium that it begins to display its peculiar properties and gives off energy. So great is the amount of this energy that there is enough of it in a pinch of radium to carry an Atlantic liner across the Atlantic at full speed. Nevertheless, by no means at present known could a pinch of radium be made to do this, since, though it contains all this amount of energy, it gives it off with extreme slowness. In order to propel an Atlantic liner across the Atlantic in six days, 100 tons of radium would be required. The question is whether we shall be able to get at the internal energy of the atom *at a fast enough rate to be of practical value.*

And now, having considered the nature and possibilities of the atom as best we might, and having been put off again and again in our attempt to answer the root question of chemistry, which is the question of the nature of matter, we must turn to the study of those very units of which atoms are composed.

The Ultimate Units of Matter. We are now quite familiar with the Beta rays of radium and other bodies, and we are able to assert that they constitute the ultimate units. The Gamma rays we may ignore, since we believe them to consist merely of an ethereal wave motion like light and the Röntgen rays [see PHYSICS]; nor need we concern ourselves with the Alpha "rays," since we are now learning to call them Alpha *particles*, and believe that they are really atomic and made up of the same constituents as the Beta rays themselves.

We may therefore concentrate ourselves entirely upon the constituents of the Beta rays. These are the ultimate units of matter. What we have already asserted about them may be easily summarised. They are probably identical in all their properties wherever found. Each either *carries* or *is* a charge of negative electricity. If the latter be true, then the ultimate units of the atoms of matter are atoms of electricity.

M. Poincaré's Remarkable Work. It is precisely this point that is now being determined. For a provisional answer to it we can scarcely do better than turn to certain French students, remembering that the history of science has taught us how lucid and brilliant are French men of science in these matters. The late M. Henri Poincaré, whose cousin is now President of the French Republic, was, in our time, the most distinguished combination of scientist and philosopher. His remarkable book "Science and Hypothesis" was translated into English in 1905; and the reader who proposes to plumb to their depths the problems to which he has been introduced in this and its companion course will do well to acquaint himself with M. Poincaré's thinking. On page 165 (English translation—the Walter Scott Publishing Co., Ltd.) M. Poincaré says: "It is true that in the electrons the electricity is supported by a little—a very little—matter; in other words, they have mass." That is all that can be obtained on this particular point from this remarkable volume, but physicists have advanced since those words were written. Is it really the fact that the electricity of the electrons is supported by even a very little matter? It is certainly the fact that these electrons or corpuscles have mass, and, writing now a decade ago, M. Poincaré assumed, as everyone did assume, that wherever there was mass there was matter.

AT THE DEATH-BED OF THE ATOM: MEASURING RADIO-ACTIVITY BY MADAME CURIE'S METHOD

"The End of Matter." The question now, however, has taken a new form. Is it necessary to assume the existence of *anything* but electricity in order to explain the known mass or inertia of the electron or negatively electrified corpuscle? Are its mass and inertia anything more than electrical mass and electrical inertia? M. Poincaré himself contributed an article upon it, in his brilliant French, to "The Athenæum." He called that article by the sensational title "La Fin de la Matière" (The End of Matter). It consisted of a masterly summary of the most recent work, the probable conclusion of which was that when sufficient of the mass and inertia of the electron have been allotted to satisfy the demands of electricity, there remains none whatever to be allotted to matter. Hence, M. Poincaré ventured to speak of the "end of matter." The root question of chemistry is the nature of matter, which has been regarded as an ultimate since men began to think, and the nature of which has been a subject of speculation for nearly three thousand years; and the answer of contemporary science is that matter is not an ultimate at all, but is a form of electrical phenomenon.

The author of a volume which has now become famous—"L'Evolution de la Matière"—has coined the phrase "the dematerialisation of matter." Both this book and M. Poincaré's "La Science et l'Hypothèse" are published in the "Bibliothèque de Philosophie Scientifique." Both have been translated, but are much preferable in the original for the reader of French. As Mr. Balfour lately put it, "matter has not been merely explained, but explained away." We must inquire into this.

The Fate of the Electron. A few pages back we raised the question, in discussing the doctrine of the conservation of matter, as to the fate of electrons. It was pointed out that we can no longer assert the doctrine of the conservation of matter to be true "in the same breath as that which serves us to say that negative electrons are shot out from unstable atoms such as that of radium, and go—whither? Do they disappear? Are they annihilated? Are they dissolved into ether, the 'mother of matter,' or are they conserved as such?" Now, what help does M. Gustave Le Bon afford? In the following paragraphs we shall freely paraphrase from M. Le Bon (French edition, 1905, page 292, etc.).

It looks as if the last term in the dematerialisation of matter were the ether, into the bosom of which, so to speak, the negative electron shot out from a decomposing atom is plunged. What is the fate of the atom of electricity—the electron or negatively electrified corpuscle—after the dissociation of matter? Does it remain eternal, when matter no longer exists? If it retains its identity, for how long does it do so? And if not, what becomes of it? It is scarcely conceivable, and is certainly quite improbable, that these electrons retain their identity. They must lose their individual existence and disappear. "Such is, without doubt," says M. Le Bon, "the ultimate fate of the electric atom (the electron). When it has radiated all its energy it vanishes in the ether and is no more."

The Last Stage of Matter. Furthermore, M. Le Bon points out that in the course of the movements of electrons and their loss of energy various forms of vibrations of the ether are observed, such as the Hertzian waves, radiant heat, visible light, invisible ultra-violet light (to which we may add the Röntgen rays). The nature of all these is the same. "They are comparable to the waves of the ocean, which differ in size alone. These ethereal vibrations, always accompanying the electric atoms (electrons), very probably represent the form under which they vanish in radiating their energy." "Thus," says M. Le Bon, "the electron, having its own individuality and a definite and constant mass, must constitute the last stage but one in the disappearance of matter. The last will be represented by the vibrations of the ether—vibrations possessing no more permanent individuality than the waves which are formed in water when one throws in a stone and which soon vanish."

The last question, or almost the last, is this: How, exactly, can we conceive of the transformation of the electron into ethereal vibrations? There are many considerations which conduce to the belief that these ultimate particles may be compared to whirlpools thus, the vortex atom theory of Lord Kelvin may well remain, though transferred from the atom to the electron. "The question, then, reduces itself to this: How can an eddy, or vortex, formed in a fluid, disappear in this fluid while producing waves in it? Thus stated, the problem is intelligible. In fact, one sees easily enough how an eddy formed in a liquid is able, when its equilibrium is troubled, to vanish while radiating the energy which it contains under the form of waves in the medium which surrounds it. It is in this fashion, for instance, that a waterspout formed in a liquid vortex loses its individuality and disappears in the ocean." We cannot do better, than quote from the paragraph with which M. Le Bon closes this section of his book.

The Atom's Secret. "It is, without doubt, so also with the ethereal vibrations. They represent the last word in the dematerialisation of matter, that which precedes its final annihilation."

And in taking leave of him we may also quote the final paragraph of his book:

"It is in this atomic universe, of which the nature was so long unknown, that we must seek the explanation of the greater part of the mysteries which surround us. The atom, which has not the eternity allotted to it by ancient beliefs, derives its power otherwise than from the properties of indestructibility and immutability. It is no longer an inert something, the blind sport of universal forces. On the contrary, it creates those forces. It is the veritable soul of all things. It holds in check energies which are the mainspring of the world and of its inhabitants. In spite of its insignificent minuteness, the atom, perhaps, holds all the secrets of infinite greatness."

C. W. SALEEBY

The Changing Fortunes of Bohemia, Poland, Lithuania, and Muscovy. The Advance of the Ottomans, Mongols, and Turks.

POLAND, RUSSIA, AND THE TURK

We now turn from South-eastern to Central Europe, which, as early as the seventh century, seems to have been peopled by numerous branches of the Slavonic family, but of these only the two principal ones, the Czechs and the Poles, need here occupy us. In the middle of the seventh century we find the Czechs located in the modern Bohemia, and owning some loose allegiance to Charles the Great. From Germany also they received their Christianity about 814, the traces of the earlier mission of Cyril and Methodius having vanished irretrievably; and till 973, when the bishopric of Prague was established, the vast Bohemo-Moravian realm, which then extended as far as the modern Galicia, was ecclesiastically part of the diocese of Ratisbon.

Bohemia was never able to found a permanent Slavonic state in Central Europe. German influences were too potent and too close at hand, and, besides, as already mentioned, the intrusion of the Magyars cut her off from her natural allies, the southern and eastern Slavs. German proximity was not, indeed, an unmixed disadvantage. To it Bohemia owed her relatively superior culture—the first German university was actually founded at the Bohemian capital, Prague, in 1349—and, more than once, especially during the brief but brilliant domination of the Premyslidæ (1197-1278), rose, by means of it, to an unlooked-for degree of grandeur. But she was rarely more than one of several competing states of almost equal strength, which were for ever confederating against any neighbour which might happen, temporarily, to be a little the stronger.

Matters were also very complicated by dynastic amalgamations. Thus, the Hapsburg dukes were frequently kings of Bohemia as well as emperors of Germany, while Hungary and Bohemia were more than once united under the same sovereign, to the serious detriment of both. No wonder, then, if the politics of Central Europe, from the thirteenth to the sixteenth century, were in a continual state of flux, and neutral intermediate provinces like Moravia, Silesia, Lusatia, Styria, and Carinthia, all of them Slavonic lands originally, were perpetually changing hands, belonging by turns to Bohemia, Hungary, and Poland, till the German element, as represented by the Hapsburg dukes, grew strong enough to subordinate the scattered Slavonic elements everywhere and altogether.

Bohemia was saved from actual absorption partly by her strong natural frontiers, a bastion of mountains protecting her on three sides, and partly by the extraordinary vitality of her Slavonic population. This was notably the case during the Hussite Wars, when the Czechs became a terror to all the surrounding states. At a later day the Czechs supplied Central Europe with its finest mercenaries—the so-called *zsebraks*.

We possess no certain historical data relating to Poland till the end of the sixth century. It would seem that the progenitors of the Poles, originally established on the Danube, were driven thence to the still wilder wildernesses of Central Europe, settling finally among the forests and morasses of the basin of the Upper Oder and Vistula, where they dwelt in loosely connected communities till the pressure of rapacious neighbours compelled them to combine for mutual defence under the semi-mythical Piast and his successors. The Piasts wrested Chrobacya, a province extending from the Carpathians to the Bug, from the shadowy Moravian empire already mentioned. Under Miszko I. (962-992) Poland nominally accepted Christianity from the Greek Church, but was reconverted by the Roman Church at the instigation of Boleslaus I. (992-1025), in order to obtain the protection of the Holy See against the persistent pressure of the Germans from the west.

Boleslaus was also the first Polish king, and he founded an empire which extended from the Baltic to Volhynia, and from the Elbe to the Bug. This empire persisted in its main outlines till the death of Boleslaus III. (1102-1138), whose last act

was to subdivide his territories among his numerous sons, who re-subdivided them among their children. "This partitional period," as it is called, lasted till 1305, during which period Poland ceased to be a political entity. By the time that the kingdom was reconstituted by Wladislaus Lokietek (1306–1339), the Teutonic Order had excluded Poland from the Baltic, and a new state, Lithuania, had intervened between her and her ancient neighbour, Russia.

The Lithuanian Monarchy. The Lithuanians, an Aryan but not a Slavonic race, originally dwelt among the impenetrable forests and morasses of the Upper Niemen, where they were able to preserve their original savagery longer than any of their neighbours, and foster a tenacious and enterprising valour which made them very formidable to all the surrounding states. They first emerge into the light of history at the time of the settlement of the Teutonic Order in the north. Rumours of the war of extermination waged against their near kinsfolk, the wild Prussians, by the Knights first awoke them to a sense of their own danger. They immediately abandoned their loose communal system for a monarchical form of government, and under a series of exceptionally capable princes, notably Mendovg (1240–1263) and Gedymin (1315–1341), began an astonishing career of conquest, so that, at the death of Gedymin, the grand-duchy of Lithuania, as it was henceforth called, extended from Courland to the Carpathians and from the Bug to the Dniester, including the old Russian principalities of Polock, Kiev, and Chernigov.

The Downfall of the Teutonic Knights. Poland and Lithuania were naturally drawn together by their common fear and hatred of the Germans, sentiments even strong enough to bring about a personal union of the two autonomous states under the Lithuanian Grand Duke Jagiello, or Jagellon, who took the name of Wladislaus II. on the occasion of his baptism and coronation at Cracow in 1386.

The cardinal political event of East Central Europe during the next century was the duel *à outrance* between Poland-Lithuania and the Teutonic Order. Ultimately decided in favour of Poland, it was, nevertheless, but a half-victory, for while the Knights were compelled to relinquish their grip on the modern Courland, Samogitia, and West Prussia, they were permitted, as the vassals of Poland, to retain possession of the modern East Prussia, or Ducal Prussia, as it was now called, when, in 1525, the last Grand Master of the Order became the first Duke of Prussia, with his capital situated at Königsberg.

European Ignorance of Russia. This partial triumph was due entirely to the foresight and tenacity of the princes of the House of Jagiello, who steadily recognised that unification, and the possession of a seaboard, were the essential conditions of the maintenance and stability of the Polish commonwealth. But in the meantime the existence of another vast state in the depths of the Polish hinterland was barely suspected in Western Europe much before the end of the fifteenth century. Muscovy may be said to have been discovered, about the same time as America, by a German traveller, Ritter Niklas von Poppel, who, in 1486, brought to Vienna the strange tidings that North-eastern Russia was not, as generally supposed, a part of Poland, but a vast independent state even larger than Poland. Yet the beginnings of the Russian empire had been far more brilliant in promise than those of the Polish kingdom.

The Ups and Downs of Early Russia. While the progenitors of the Poles were struggling in their native swamps, the progenitors of the Russians were alternately the adversaries and the allies of the Greek emperors of the East. As early as the tenth century the court of Yaroslav, the son of Vladimir the Great, was renowned throughout Europe as much for learning as for splendour, and the kings of France, Hungary, and Norway were suitors for the daughters of the grand duke of Kiev.

But after the destruction of Kiev by the Tartars evil days fell upon "the land of the Rus." The current of the national life was now forced to flow north-eastwards instead of following its natural south-western course as heretofore. It was in the rude climate and among the vast virgin forests of the plain of the Upper Volga that the Russian princes, cut off from Western civilisation, began, painfully and laboriously, to build up again the Russian state. For generations to come they were the tributaries and the vassals of the Tartar khans. Nor did their own hands deliver them.

It was the victories of the Lithuanian princes which compelled the Tartars somewhat to relax their grip on South-western and Central Russia, and the provinces so released fell, naturally, to the victors. Thus it came about that by the time the northern princes had established a fresh centre of nationality and orthodoxy under the leadership of the patient and strenuous grand dukes of Moscow, at least one-half of the old Russian lands, with their Orthodox Slavonic population, had become part of Lithuania, a foreign state, and, still worse, the ally and consort of Catholic Poland.

Russia as "a Geographical Expression." In fact, from the end of the fourteenth to the middle of the eighteenth century the term "Russia" is merely a geographical expression with various significations. As used by the Poles, it invariably means the woiwody, or palatinate, of Red Russia, which extended, roughly speaking, from the watershed of the Upper Vistula to the watershed of the Pruth. As used by the Muscovites, it meant all those Russian lands outside the actual limits of the grand duchy of Moscow, which the grand duke claimed as the descendant of Vladimir; that is to say, Black Russia, Red Russia, Little Russia, and White Russia, by far the larger portion of which had been incorporated either with Lithuania or with Poland. Hence the peculiar significance of the coveted title "Sovereign of All the Russias."

A SMALL STATE LOSES ITS INDEPENDENCE—THE UNION OF POLAND AND LITHUANIA

LITHUANIA WAS JOINED INDISSOLUBLY TO POLAND BY THE DIET OF LUBLIN IN 1569. WHEN THE PARTIES TO THE TREATY MET, THE LITHUANIANS, AS THE OATHS WERE ADMINISTERED, SHED TEARS OF SORROW, AND THE POLES TEARS OF JOY

The Part Played by the Tsars. The highest encomium which the old Muscovite chronicles could bestow upon a prince in those miserable days of anarchy and dispersion was to describe him as a "*sobiratel*," or "gatherer," of the provinces which, taken together, formed the original heritage of the Russian people. All the old Muscovite grand dukes and tsars from Ivan I. to Ivan IV. (1328–1584) were more or less successful "gatherers" of land. They were, generally speaking, a stealthy, crafty, cowardly race. Indeed, personally they seem contemptible by the side of the heroic and sagacious rulers of contemporary Poland. The means such men employed to gain their end were almost necessarily base and vile in the extreme, but the end invariably aimed at—the unification and civilisation of Russia—was indisputably a high one; and whatever their vices, patriotism, the highest virtue of a statesman, cannot be denied to the worst of them.

IVAN THE TERRIBLE SHOWING HIS TREASURES TO THE BRITISH AMBASSADOR

Moreover, they were popular, for they stood between the people and the people's secular oppressors, the official classes. So far as their arm could reach, the people were protected, and rough justice was generally done. Thus, on the whole, it is no hyperbole to declare that whatever of glory and prosperity she may possess, Russia owes it almost entirely to the initiative of her autocrats.

Polish and Russian Rivalry on the Baltic. In the very nature of things, the history of Poland and Muscovy was bound sooner or later to resolve itself into a struggle for the possession of the alienated Orthodox Russian provinces. At first, however, this struggle was desultory and intermittent. Other questions more immediately urgent postponed the final settlement. Poland could not give proper attention to the Muscovite question, still of but secondary importance, so long as the Prussian incubus thwarted and crippled her nearer home; while till Muscovy had freed herself from the paralysing Tartar yoke, she could do little more than harrow and vex the Lithuanian borders. The inevitable antagonism between the two peoples was exacerbated by the determined attempts of Muscovy to gain an adequate seaboard on the Baltic, on the collapse of the Livonian Order, and the equally determined efforts of Poland to prevent her rival from becoming wealthier and more civilised by means of maritime commerce and free intercourse with the west of Europe.

Russia Ready for European Expansion. By this time Muscovy had dealt a mortal blow at the Tartar domination. The overthrow of the khanate of Kazan by Ivan the Terrible, in 1552, was, perhaps, no very extraordinary exploit from a purely military point of view; nevertheless, politically, it was an epoch-making event in the history of Eastern Europe. At Kazan, Mohammedan Asia had fought behind its last trench against Christian Europe marshalled beneath the banner of the Tsar of Muscovy. Nothing could now restrain the natural advance of the young Russian state towards the east and south-east.

A New Menace to the Moslem World. Throughout the crusading era, the twelfth and thirteenth centuries, Islam had not been a menace to Christendom. The Western, not the Eastern powers, were the aggressors; though had Saladin been succeeded by another Saladin a different situation might have arisen. The East continued to be divided, and even in the beginning of the thirteenth century, a few years after Saladin's death, the khalifate was threatened by a new and terrific power which was not Moslem at all. Before the year 1200 the mighty warrior Temujin, better known by the title he assumed of Genghis or Zenghis Khan, had united under his own leadership vast hordes of the nomad Mongolian or Tartar tribes of Central Asia, in regions lying beyond the sphere of the khalifate.

The Conquests of Genghis Khan. Genghis Khan was of the same race and the same type as Attila the Hun. Huns and Tartars were destroyers, not organisers, but they were terrible fighting men. And when Genghis Khan had crushed all rivals he set out on a career of conquest, accompanied wherever he met with resistance by the most fearful massacres. His armies swept East and West. He conquered Northern China and burst into Persia. He broke southward through the passes into the Punjab, but stopped his course of conquest in that direction in order to turn again to the Far East. A few years after his death, in 1227, the Mongols were masters of China, which fell to one of his children, Khubla Khan, a great ruler whose name has been made familiar by Coleridge's poem and whose glories were made known to the Western world by the great traveller Marco Polo.

The Tartar Overthrow of Russia. But the Chinese Empire was only a part of the vast Mongol dominion. Before the middle of the thirteenth century the Tartars were pouring over Southern Russia and Eastern Europe. In 1240 they destroyed Kief, and in 1241 they wiped out a force of Germans and Poles near the borders of the German empire at Liegnitz. They turned their erratic course into Hungary; but on the news of the death of the Great Khan, the head of the whole confederacy, the armies, without any other apparent reason, rolled back over South Russia to the Steppes, the regions on the borderland of Europe and Asia. They had absolutely annihilated all prospect of progress among the Russians, who remained in a condition of disorganised subjection to them for several centuries.

Egypt's Resistance to the Mongol Raids. Under another of their chiefs of the royal House, Hulagu, they found an excuse in the second half of the thirteenth century for attacking the khalifate, and finally putting an end to the Abbaside dynasty after sacking Baghdad and massacring its inhabitants. To the Western world it seemed for a time possible that the Mongols might be useful allies against Islam. But the tide of their advance was unexpectedly checked. The Mongol army poured into Syria and advanced against Egypt, where a Fatimide khalifate had been established. But the defence was undertaken by the Mamelukes, the bands of slave soldiery formed from the children of deported populations. The Mameluke captain annihilated the Tartar force; and from thenceforth Egypt remained under the control of the Mamelukes, who for more than two centuries set up or deposed one or another of their captains

THE COSSACKS REPLYING TO A LETTER OF THE SULTAN

who ruled for a time. But throughout the continued anarchy the Mameluke army remained supreme, defiant of attack alike from the East and from the West.

The Rise of the Ottoman Power. As in the time of Attila, the Mongol tide rolled back again out of Western Asia. One element among the forces which turned them back was the resistance offered to them by the kingdom of the Seljuk Turks in Iconium, the east of Asia Minor. The strength of that resistance had been mainly owing to the help received by the Seljuks from a horde of their own Turkish kinsmen who came down into Asia Minor through Armenia. The leader of these Turks was Othman, who was established by the grateful king of Iconium in a virtually independent principality, with the result that the Osmanli, or Ottomans as they are commonly called in England, became the dominant Turkish power. By 1340 the Ottomans had torn practically all but a strip of Asia Minor from the Greek empire.

The Ottoman Tribute of Slaves. The successes of the Ottomans were largely due to an institution created by Othman's successor, Orchan. Moslem conquerors had the one fixed principle of compelling the conquered either to accept Islam or to pay tribute. Orchan exacted the tribute in the form of slaves. Every district was required to hand over annually a number of boys. Those boys were either trained to arms and enrolled in the body of "Janissaries," or else were trained to employment in administration. All of them being absolutely under the control of the Sultan, he had at his command an incomparable body of troops and administrators absolutely at his service.

Ottoman Aggression in Europe. In 1354 the Ottomans for the first time seized and occupied at Gallipoli a position in the European territories of the Greek dominion. Within a few years they had captured Adrianople, which became the centre from which they gradually extended their dominion. Western Europe, engaged in its own politics, left the East severely alone, unmoved by the progress of the Crescent; and the Ottomans gradually made themselves masters of the Danube provinces. In 1390 Bajazet I. became sultan, and overthrew a great combination of the Slavonic states which attempted to resist his advance; and even the emperor at Constantinople was compelled to pay him tribute. His recalcitrance, however, caused Bajazet to lay siege to Constantinople, but the Sultan was called away to face the incursion of a new conqueror from Central Asia, Timur or Tamerlaine the Turk or Tartar, who was emulating the career of Genghis Khan. But Bajazet was defeated and taken prisoner by Timur at the battle of Angora in 1402. This blow to the Ottoman power weakened its aggressions for half a century.

The Revival of Ottoman Power. The Western world was disposed to regard Timur much as it had regarded the Mongols a century and a half before. But the Tartar host dispersed again when Timur died. Within twenty years the Ottomans had shown their power of recuperation and were re-establishing their European dominion. Still, when the Sultan Amurath again attacked Constantinople, in 1452, he was beaten off with heavy loss. Again, however, Constantinople preferred a practical submission to a desperate defiance; the Ottomans turned their arms against the Slavs and Hungarians, who, in the forties, under the leadership of John Hunyadi, inflicted upon them severe defeats, liberated Servia and Bosnia, and compelled the sultan's assent to the annexation of Wallachia to Hungary. The tables were turned again, however, when the over-confident Christians repudiated the treaty and attacked the Ottomans. Their forces were routed, and Servia and Bosnia were annexed by the sultan.

The Siege and Fall of Constantinople. In 1451 Amurath was succeeded by his son Mohammed II., who immediately prepared for the final subjugation of Constantinople. The feeble emperor John had been succeeded by his heroic brother Constantine, who was determined to defend the imperial city to the last gasp. He attempted to gain the friendship of the Western powers by a reconciliation with the Western Church, which only served to arouse the bigotry of his own Greek subjects, who would render no whole-hearted support to a heretical emperor, or an emperor who would make terms with heretics. From the West no aid was forthcoming save from Venetians and Genoese, who provided the real strength of the garrison of Constantinople. The siege opened in the spring of 1453. A Genoese flotilla broke through the Turkish fleet and carried supplies into the beleaguered city. But this was the last success. On the 29th of May the Moslems stormed the walls and carried them. Constantine fell, fighting heroically at the head of his garrison; the Turks swept in. Constantinople had fallen. Within ten years the whole of Greece and the Balkan peninsula were practically under the sway of the Turkish sultan.

The Supremacy of the Turks in the Levant. A splendid resistance to the Turks had been offered in the years before the fall of Constantinople by the valiant and patriotic Albanian chief who is immortalised under the name of Scanderbeg. But after the death of that hero the subjugation of Albania was merely a question of time. The maritime vigour of Venice enabled her to retain by treaty some of her possessions in the south of Greece, and the trading concessions which had been made to her by the Greek emperors in Constantinople. But virtually the whole of the Ægean passed to the possession of the Turk. Nor was Mohammed contented with his European conquests. As much of Asia Minor as had hitherto remained independent of the Ottoman power was brought into complete subjection; and then he seized and garrisoned Otranto. Still for a time the advance was stayed by his death. His successor Bajazet II., who lived till 1512, was the least vigorous member of his dynasty, and Otranto was again evacuated.

Tools and Implements. Hand and Mechanical Labour. Barrow and Waggon Handling. Details of Tipping.

RAILWAY EARTHWORKS

THE *earthworks* of a railway usually account for about a fourth or a fifth of the total cost of construction. It is here that the greatest scope is afforded for skilful and experienced management. One who contracts to build a railway will usually be found to succeed or fail according to the ability with which he effects the shifting of the earth.

The actual conditions under which a railway is built are never ideal. However typical the situation may be, untoward circumstances always interfere with whatever arrangements may have been made to build in a preconceived manner that aims at theoretical perfection.

The builder of a railway must, therefore, be resourceful in expedient, and his arrangements must be elastic. Makeshifts are his standby, his main equipment, as a practical man. One who knows only how to proceed by perfectly correct methods is sure to come to grief; and although it is impossible to expound the infinite variety of makeshifts, we shall not follow the usual plan of omitting the description of makeshift devices.

Strength of Earthworks. Earth gives way by reason of the particles of which it consists sliding past each other. This is prevented in two ways: first, by any adhesion which may obtain between the particles, and secondly, by friction. It must be remembered in this connection that solid rock, wherever met with, is included in the general meaning of earthwork as well as ordinary clay, marl, loam, and such soil. In the case of solid rock the force of cohesion is, of course, sufficient to preserve the work in almost any form that may be given to it; though it must be noted that rocks have joints and fissures, and that the material may slip where these occur.

With ordinary earth the force of cohesion may also sometimes be considerable; but seldom, if ever, can it be relied upon as a permanent factor in the preservation of the work. It is in all cases greatly diminished by the presence of water, though often assisted by a moderate amount of moisture; and certain clays, though hard and stiff enough when first excavated, become soft and pasty by mere exposure to the atmosphere.

Natural Slope. The only force that can be relied upon for the permanent preservation of earthwork is the friction between the particles composing it. This is sufficient to maintain the side of an earthwork at a uniform slope, whose inclination to the horizon is the angle of repose, or angle whose *tangent* is the *coefficient of friction.*

This angle differs, of course, for every kind of earth, and is so variable that tables or information obtained from books should never be trusted to determine the slope at which the side of an earthwork should be made. In every case observation should be taken of existing earthworks constructed of the same material, or, in default of these, the greatest inclination of the natural surface of the soil in the locality may prove an even more satisfactory guide.

For the purpose, however, of obtaining a general idea of the behaviour of materials most commonly found, the following table may be consulted. The first column shows the greatest height in feet at which the material can be expected to stand *temporarily.* The second column shows the greatest angle at which it can be relied upon to remain permanently in repose:

	I.	II.
	Feet	Degrees
Clean dry sand and gravel	0	36 to 45
Moist sand	3 to 5	36 to 45
Ordinary surface soil..	3 to 6	25 to 40
Common clay ..	9 to 15	30 to 40

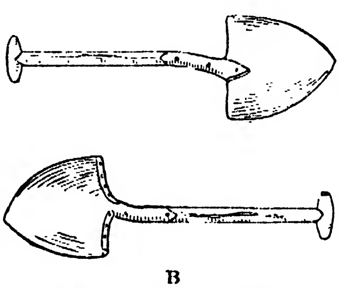
Getting. The word *getting* is commonly used to mean the removal of earth from its natural position, to transport it in the manner and to the place required by the exigencies of railway construction. The mere getting of earth is most economically effected by means of a steam navvy. The steam navvy, however, can be made to work in an economical and satisfactory manner only when it can be used against a sheer face of earth. Hence, as in most cases where a cutting of earth is to be begun, the earth begins to rise gradually, and in many cases very gradually, the depth of the cut being at the beginning but slight, so that a good deal of work has to be done first of all by hand labour.

Whatever recourse may be had to machinery, there is always a great deal of hand labour required in the shifting of earth for railway construction. The cost of this by itself amounts to a considerable sum, the amount of which is entirely determined by the skill with which the work is arranged. The main feature of good management is to insure that all hands are always fully engaged, and that under no circumstances have men to wait while their work is in preparation.

Implements. The suitability of the tools for the work is also important. Even the common and well-known pick, unless it be adapted to the work in hand, will involve an

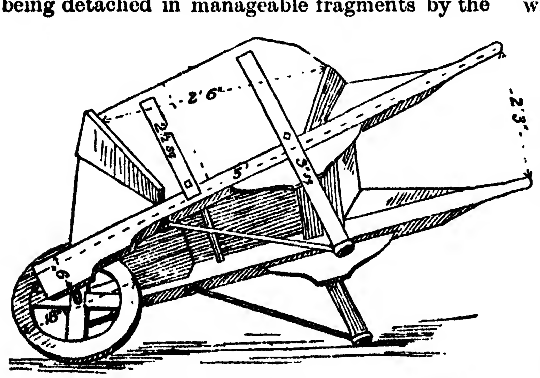
unnecessary expenditure on labour. There are three kinds of pick in common use; those most favoured are A and C in 1. In getting stiff earth the pick is used a great deal as a lever and is very liable to break at the junction of the handle with the steel. For this reason the pick A is most suitable under these conditions; but that indicated by C is more suitable for all-round general work, and is most favoured by workmen. The pick B is most convenient for work that is level under foot. It will be recognised as that most frequently seen in the hands of workmen mending macadamised roads. It is a common plan in America to plough the land before putting the men on; the object of this is to loosen the surface soil, thus avoiding the use of the pickaxe at all. Such a method is, of course, only applicable where the depth to be obtained is very slight, as, for example, occurs in cases where it is considered desirable that the surface soil should be removed before commencing an earthwork.

Shovels and Spades. Two kinds of shovel are required, and they are illustrated in 2. They are not of uniform size, the dimensions varying from 12 in. by 10½ in. to 14 in. by 13 in. The main difference between them is that B is provided with treads—that is to say, an extra piece of metal is placed on the top of the blade where the navvy places his foot to drive the shovel into the earth. These treads lengthen the life of the shovel, especially when used for digging in hard soil; but for shovelling earth into barrows or carts, the treads are superfluous and, by adding to the weight of the implement, cause an appreciable increase in the labour of using it.



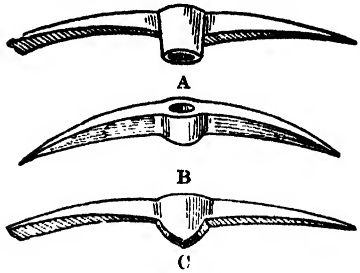
2. RAILWAY SHOVELS

A spade, including the handle, should not weigh more than about 6 lb. The earth, after being detached in manageable fragments by the



3. WHEELBARROW FOR RAILWAY WORK

pick is placed by means of shovels into either wheelbarrows or small carts, except where the cutting is sufficiently advanced for men to be able to throw the earth immediately into waggons running upon the rail. The latter plan is adopted directly the *gullet*—as the advancing cut into the hill is called—is 4 ft. or 5 ft. deep, provided a proper *tip-head* is prepared. The use of this latter term will be fully explained when we deal with the subject of tipping.



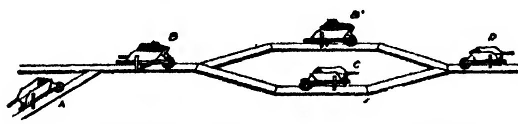
1. PICKS USED FOR RAILWAY WORK

Wheelbarrows. The great point in the design of a wheelbarrow is the distance of its centre of gravity when loaded from the line joining the point of contact of the wheel and the ground to the handles. If this be too great, the workman will find a difficulty in balancing it, and the effort to keep it steady will diminish his daily output of work. The distance in question should certainly not exceed 12 in.

Hand Labour. A wheelbarrow of serviceable size is shown in 3. The men who use picks are called *pick-men* or *getters;* those who use a shovel are called *fillers;* and when wheelbarrows are used the men wheeling them are called *wheelers.* The number of getters must be carefully proportioned to the number of fillers, and the number of these to the number of wheelers, so that the different groups may not have to wait for each other. The proportion of getters to fillers depends upon the nature of the soil. In comparatively new earth an equal number of each will generally keep everyone employed. In a stiff clay, however, one filler will clear away the getting of two pick-men. Only by experience can a suitable relation be obtained. The proportion of the number of wheelers to the number of fillers depends upon the *lead*—that is to say, upon the distance over which the earth has to be wheeled. As a general rule, it takes as long to fill an ordinary barrow as to wheel it along a plank for 100 feet. This, however, only holds good if the plank be level. If the earth must be wheeled up an incline, every foot of increase in the level must be reckoned equivalent to 8 ft. on the level plank. The lead should be so arranged that under no circumstances have loaded barrows to be wheeled up an incline greater than 1 in 12, otherwise the workmen will not be expending their strength in an economical manner.

Barrow Work. When earth has to be transported in barrows a greater distance than one wheeler can go while a filler is filling the barrow, the lead is divided into two, or a greater number of parts, as the case may require. These parts are commonly referred to

as *runs*. Where the runs meet, the planks are laid double for a short distance. Thus, in 4 the barrow A is being filled, while the barrow B is being wheeled away full. When the barrow B has reached the position B¹, it will be left there, and C, the empty barrow left by



4. TRANSPORTING EARTH IN WHEELBARROWS

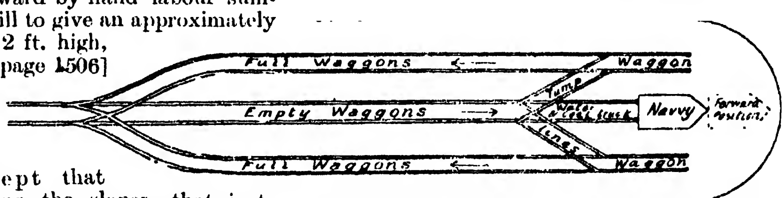
the second wheeler, will be taken back to be refilled by the first. The second wheeler, meanwhile, having placed the empty barrow D he is now taking back in the old position C, will take on the barrow B from its position at B¹. In the figure the barrows are shown turned in the direction of movement; but the English labourer does not so turn his barrow, but trundles it behind him when returning with it empty.

The Steam Navvy. As soon as a cutting has been pushed forward by hand labour sufficiently far into the hill to give an approximately vertical face about 12 ft. high, a steam navvy [see page 1506] may usually be introduced with economy, and all further getting, filling, and barrow work, except that required for *trimming* the slopes—that is to say, bringing them to their ultimate profile—is done by its means.

The steam navvy enables quicker progress to be made than is possible by hand labour, however great a number of men may be available for the work, since it is impossible to get more than a certain number of men at work upon a face of earth at the head of a cutting; and by means of the steam navvy the earth is excavated very much more quickly than it could be by this maximum of men. Its use relieves the contractor of the necessity of getting together so large a number of men, and of housing or otherwise providing for them in out-of-the-way districts. It further renders the contractor or constructor of the railway in a great measure independent of strikes in this department of his business, so that less time is lost in disputes about wages. Thus, when a steam navvy has once been got fairly to work in excavating a railway cutting, it may generally be relied on to continue at a uniform rate of progress until the excavation of that cutting is complete.

Output of the Steam Navvy. The output is, of course, greatly dependent upon the nature of the earth. For hard stuff a small bucket must be used. But in most cases the bucket attached to the steam navvy may be of 1¼ cub. yd. capacity, and in loose earth or sand a bucket of 1½ or even 1¾ cub. yd. may be used with advantage. The most disadvantageous material to work is stiff clay containing large stones and occasional boulders. In such cases the capacity of the bucket should not exceed 1 cub. yd., and may have to be even less in order to reduce the liability to accidents. The number of strokes or digs that can be effected in an hour is between 50 and 70, and the average is about one a minute, allowing for all the delays involved in moving forward the machine and in laying fresh rails, etc. This gives approximately 600 bucket-loads per day of 10 hours. Under fairly favourable conditions a steam navvy will excavate a cutting 20 ft. deep, 50 ft. wide at the top and 40 ft. wide at the bottom at an average rate of 8 lineal yd. per day. As to the cost, it is to a great extent a matter of wages. The machine requires a wheelman, a fireman, a man at the top, a ganger, an engine-driver, and eight other men to allow for handling the waggons and for shifts, so that altogether the cost of getting and clearing away the earth with the help of the steam navvy is about £5 a day in England.

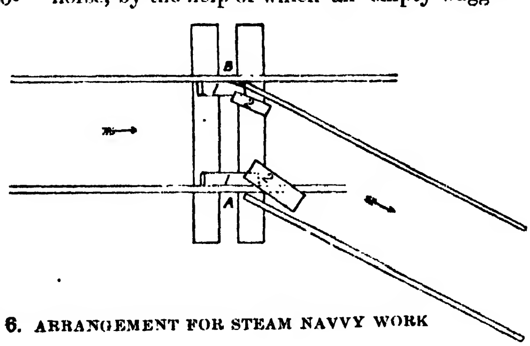
Manner of Working. To ensure that the machine shall be kept working at a maximum output, careful attention must be given to the



5. RAILWAY CUTTING WITH A STEAM NAVVY

provision for getting rid of the excavated earth The most effective way is to provide double roads, one on each side of the machine, and branching out from a central road. Immediately behind the machine these roads should be connected by two short crossover lines [5].

A line of empty waggons is kept on the central road between the two side lines, and on each side of the line of waggons is a man tending a horse, by the help of which an empty waggon is



6. ARRANGEMENT FOR STEAM NAVVY WORK

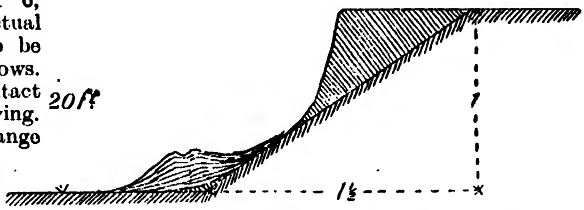
brought forward from the line on the central track over the short crossover line and alongside the machine. As soon as a waggon is filled, it is run back along the branch, another empty waggon meanwhile having been brought up alongside the other side of the machine from the central track. Thus the empty waggons are

continually being removed from the central track and passed (filled) into the branch line. Each engine bringing a train of empty waggons pushes them up the central track and leaves them there; it then goes back and passes on to the branch line to take a load of full waggons out of it.

The short crossover lines immediately behind the steam navvy have to be continually moved forward as the steam navvy works its way through the cutting. It will have been noticed that only empty waggons are passed over them, and under these circumstances it is not surprising that the roughest makeshifts are found to be economical.

Waggon Provision for the Navvy. A common arrangement is shown in 6, the details of which are taken from actual practice. The waggon is supposed to be going in the direction indicated by the arrows. The front right wheel comes first into contact with the block of wood 1 at A in the drawing. This block is shaped like a wedge. The flange of the wheel of the waggon rolls up this wedge until the bottom of the flange is on a level with the top of the rail. Further progress at A is then checked, while the left wheel rolls round B, coming up a similar inclined plane to that already described at A, because the rail it has to mount is at a higher level than that it must leave. To prevent the wheels making off bodily to the right and leaving the line, block 2 is placed at B to keep the flange in position. Both the blocks 2, 2, at A and B now help to divert the wheels so that they drop down upon a crossover line with a jolt. It will be seen from 5 that according to this arrangement the jib of the steam navvy has to be swung round a minimum distance at each stroke, the earth obtained by each sweep being delivered on its own side. The gullet thus made may be run to a depth of as much as 30 ft. in loose ground, but the most economical depth is 25 ft., because at this depth the machine has just reach enough to make the cutting of standard size for an ordinary two-line railroad of the usual gauge. It is in making the cutting very much narrower or very much broader than this that extra trouble is involved. When the cutting is narrower there is not room for a line of waggons on each side; and when it is broader, the navvy is unable to reach both sides at the same time, and, consequently, after being run forward as far as the circumstances allow, it must be brought back again and set to widening the cut by excavating on one side of it alone. While so working only one waggon at a time can be placed in position for loading, and the consequence of this is that there is loss of time in changing the waggon, since it requires less time for the navvy to fill its bucket than for the filled waggon to be moved and an empty one put in its place.

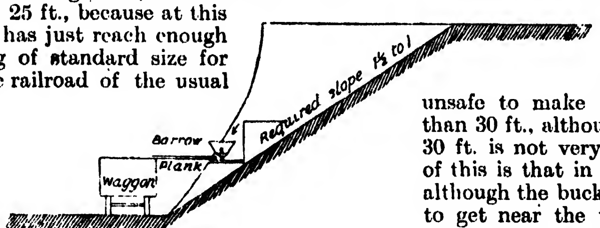
Getting the Waggons into Position. In working along a side face, as in the case just described, there are two ways of getting empty waggons into position. First, a train can be drawn up alongside the navvy, and each truck as it is filled can be pulled backwards by the locomotive, so as to bring the next one to the right position for receiving the contents of the bucket. This method has the advantage of quickness, and eliminates the loss of time alluded to. In practice, however, it is not found satisfactory, except in the hands of a very skilful engine-driver, and with a better track than is commonly laid for the waggons.



7. RAILWAY CUTTING AS LEFT BY STEAM NAVVY

Under ordinary circumstances, the engine-driver will fail to move the train just the requisite distance for bringing the succeeding truck into the right position to be filled. The steam navvy will then possibly miss a truck, the movement having been too great, or a great deal of earth may be spilt upon the track because the bucket cannot be brought properly over the misplaced waggon.

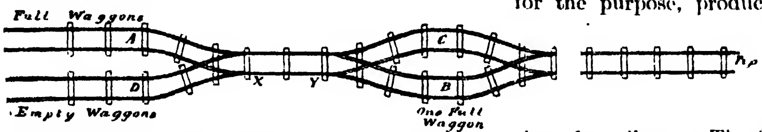
The second method is to store the empty waggons behind the navvy, very much in the same way as was described in 5, though there can be only one branch line. Of course it is not so convenient, but on the whole this method is more often used than the former.



8. RAILWAY CUTTING, SHOWING GALLERIES

Cutting in Clay. In cutting a very hard and tenacious clay it is unsafe to make the cutting deeper than 30 ft., although with loose earth 30 ft. is not very deep. The reason of this is that in digging loose earth, although the bucket may not be able to get near the top of the cutting, yet, while digging underneath, the upper part falls down; whereas in a hard clay, the digging underneath might proceed for 5 ft. or 6 ft. into the face before the earth at the top gave way, when it would be likely to fall in a mass and injure something in falling. Where the cutting is of excessive height for only a short distance, it is expedient to loosen the earth at the top by means of wedges over this distance, so that only small quantities shall fall at a time. The work will involve the employment of several men, and is very liable to lead to accidents. It is only when the distance in question is too short to make any alteration in the scheme for excavation expedient that it should be resorted to. The alternative is to take out the earth in two layers.

The Steam Navvy's Work. The steam navvy leaves the side slopes nearly perpendicular towards the top, especially when the cutting is deep, and these have afterwards to be trimmed to the proper profile as required for the railway. The most economical method of trimming is put into practice immediately after the navvy has moved on, or at least before the earth has slipped down. Fig. 7 shows the form in which the side of the cutting is left by the navvy. It will be seen that the earth is in an unstable condition, and that its fall is only a question of time. Hence, if the slopes are trimmed immediately after the navvy has left them—that is to say, before the earth has fallen—much labour will be saved, since the workmen have the force of gravity in their favour; whereas, after it has slipped down, they must throw it up again, and usually into railway waggons, which is a high throw.



9. ARRANGEMENT OF LINES FOR SINGLE TIP-HEAD

As shown in 8, galleries should be made along the side of the cut, so that the earth is always thrown downwards, and wheeled along planks as shown, and emptied into waggons alongside.

Obstacles to Steam Navvy Work. One of the chief obstacles to the use of a steam navvy in settled countries like our own arises from the number of bridges which have to be constructed over the line. These may amount to five, or even ten per mile, and frequently have to be built in trenches before the cutting is made. The steam navvy, in such circumstances, cannot be passed beneath it without being taken to pieces, involving great labour and loss of time. In excavating a stiff clay a further objection is found in the condition of the excavated earth. This will consist chiefly of large lumps, 8 cub. ft. in size, and fragments thereof. When the earth is tipped to form an embankment, the large lumps all roll down to the bottom and form the base of the bank, the effect of which is to cause an undue amount of subsequent contraction. This difficulty is discussed more fully under the head of *tipping*.

Blasting. When the earth to be excavated is too hard to yield to the pick, the assistance of explosives must be obtained. Slow-burning explosives, of which gunpowder is the type, are most suitable and economical for soft, tough rock, such as are composed of indurated clays; while detonating explosives of the dynamite order are best suited to hard, brittle rocks, like trachyte. Patent explosives consisting of mixtures of these two explosives are often more powerful than either. An account of the use must be sought for under the head of Explosives. The ordinary methods of blasting are explained under Mining, and the blasting required for railway work does not appreciably differ.

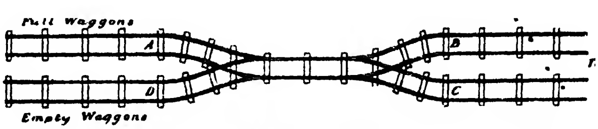
Tipping. Earth is either tipped or filled in order to be got rid of or for some ulterior useful purpose, of which the formation of an embankment is the principal. In cases where such an embankment is too far removed from the site of the excavation, or where, for any other reason, it is inconvenient to use the excavated earth for the purpose of forming an embankment or any other railway work, the earth must be tipped upon waste land purchased for the purpose, producing what is known as a *spoil-bank*.

There are two methods by which an embankment may be filled in the construction of a railway. The first is by depositing the earth in layers about 1 ft. thick, and *punning*, or *ramming*, it thoroughly after each layer is deposited. Punning, or ramming, consists of allowing a heavy weight to fall upon the earth from the height of about 1 ft., to which height it is raised by hand, the man using a staff attached to the weight for that purpose. The process is expensive, the cost being approximately equivalent to $1\frac{1}{6}$th as much as that involved in loading the earth into barrows. This method is, nevertheless, used in depositing the earth over culverts and in the proximity of bridges and similar openings.

The other method of tipping the earth is to allow it to fall from the waggon or the vehicle in which it is conveyed from the full height of the embankment which is being formed. This is a much easier, more convenient, and a less expensive method of working. It has the advantage also of being very much more expeditious.

An embankment constructed in this manner may be either tipped to its full width at once by using two lines of way, or, when the work is required to be pushed quickly ahead, a single line may be used for a short distance; but it will be seen from the following description that the single line cannot be made to go very far ahead.

Single Tip-head. The arrangement of lines for a single tip-head, as it is called, is as follows [9]: The engine first of all drags its train of loaded waggons, which it leaves at A in the figure, the line being here doubled to allow a space in which they may stand. All the waggons are then detached from one another and from the engine. The truck nearest the engine is then reattached to it, not by means of the ordinary coupling, but by means of a hook which can be detached by the engine-driver or stoker on pulling a string. The engine now proceeds with this full truck behind it,



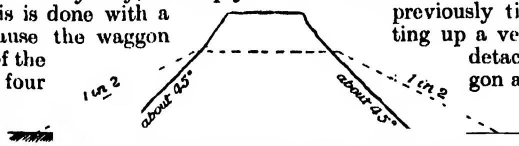
10. ARRANGEMENT OF LINES FOR DOUBLE TIP-HEAD

and moves towards the tip by way of the lines marked B. But before it reaches B the waggon is detached, and the speed is regulated so that the waggon following the engine, in virtue of the velocity already obtained, comes to a stop of itself, and is left at B. The engine, which has been proceeding towards the tip, now reverses, and returns to A by passing along the lines marked C. At A it picks up another full-waggon, and this it proceeds to leave at B by the same method as before ; but on this occasion, in passing towards the tip along the lines marked B, it comes in contact with the former waggon which had been left at this spot. This it now pushes towards the tip-head. It is not attached to the waggon in any way, it simply pushes it forward. This is done with a sufficient velocity to cause the waggon to reach the extremity of the tip at a speed of from four to six miles an hour. The engine is stopped by putting on the brakes shortly before the waggon reaches the *tip-head*, as the extremity of the tip is called. The contents of the waggon having been emptied at the tip-head, the engine again comes forward, the emptied waggon is attached to it, and the engine proceeds with it at a moderate speed along the lines marked C. Here it again detaches itself and increases its velocity, so that it gets ahead of the waggon and passes along the lines marked A, there to pick up another full waggon. In the interval the points at X have been altered so that the empty waggon following the engine is directed on to the line marked D, where all the waggons, after being emptied, are ultimately stored, by continuing the cycle of operations already described. The engine then passes along the lines marked A, enters the line marked D at the other end, and the train of empty waggons can be made up, to be carried back to the site at which excavation is proceeding in order to be refilled.

It will be seen from the figure that three points are required, at X and Y and Z ; but the points at X are the only points that require the attendance of a man, or rather a boy, to operate them. Those at Z may be operated by a weight in such a way that wheels passing from right to left are always directed along the lines marked C, while those moving in the opposite direction open the points for themselves, the pressure of the flange being sufficient to raise the weight. The points at Y can be managed in the same manner, the weight being arranged so as to direct all wheels moving from left to right along the lines marked B.

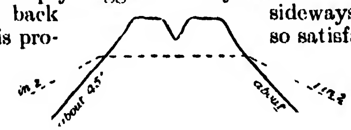
Double Tip-head. The arrangements for a *double tip-head*, as a tip-head with two lines of way is usually called, are simpler [10]. The waggons arrive at A, and are left there as before, being detatched from each other as already described. The engine, then picking up the truck first to hand, gets up sufficient speed to enable the waggon to reach the tip-head by its own velocity. This must, of course, be done quickly, for the engine must detach itself and, proceeding at a greater speed, pass on to the lines marked B, leaving time enough for the points to be altered before they are reached by the waggon following it, so that the waggon shall pass on to the line marked C with sufficient speed to reach the tip-head and be tipped.

The engine then returns, and, picking up another waggon, sends it to be tipped along the lines marked B in an exactly similar manner, while the engine itself, proceeding along the line marked C, there picks up the waggon previously tipped, and, quickly getting up a velocity on its way back, detaches itself from the waggon and moves on to the line marked A, leaving the empty waggon behind it to follow at a sufficient distance to allow the points to be altered so as to direct it on to the lines marked D, and with sufficient velocity to carry it up to the line of empty waggons standing there. In this arrangement it will be seen from the figure that only two sets of points are required, both of which, however, require manual operation.



11. RAILWAY EMBANKMENT FOR SINGLE TRACK
Showing provisional and ultimate position of earth

Side Tipping. By means of a double tip-head an embankment may be tipped at once to its full width—that is to say, the necessity for tipping over the side of the embankment may be avoided. This method of tipping earth is very simple, though special waggons are required. These waggons are called side-tip waggons, and where it is desired merely to widen an embankment it is necessary only to bring a train of them on to the embankment, when they are all caused to tip their contents out sideways. This means, however, is not so satisfactory, in spite of its simplicity and economy. The objection consists in the fact that earth has always a tendency to slip in the same direction in which it falls from the waggon, and if, for any reason, the widening of an embankment by side tipping is not completed until some time after the first work has been made, it is possible that the earth subsequently deposited may never become securely united to the previously tipped earth. The effect of heavy rainfall under these circumstances may be to cause a very serious slide in the earth of the embankment, and perhaps a grave accident.



12. RAILWAY EMBANKMENT FOR DOUBLE TRACK
Showing provisional and ultimate position of earth

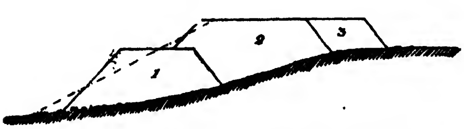
Tipping Embankments of Various Widths. In tipping an embankment for a single line of way the width at the top is generally much narrower than is necessary for the support of the permanent way to be subsequently built ; on the other hand, the earth falls down from the waggons from which it is tipped at an angle very much steeper than will provide for the

necessary stability of the permanent earthwork. Under these circumstances it is usual to tip an embankment which is formed under these conditions considerably higher than it is intended ultimately to be. The surplus earth at the top will then be available for easing the slope at the side, as shown in **11**, in which the full lines show the profile of the embankment as at first formed, and the dotted lines as subsequently shaped.

In tipping a bank for two lines of way, it is best to keep the two tip-heads at a good distance apart, as shown in **12**, so that at the top the bank is at first much broader than is required. The full line in the figure shows the profile of the embankment as at first formed, and the dotted lines show the profile as finally shaped. The triangle between the two heads is best filled by running a single tip-head in a line between the two former tip-heads.

Embankments on Sidelong Ground. In **11** and **12** the level of the earth upon which the embankment is tipped has been shown level. This, of course, is seldom the case, and if the slope of the ground in the sidelong direction is considerable it will be necessary to bench it, or cut it into steps [**13**], which should be sloped longitudinally for drainage, in order that the earth tipped upon it may get a firm hold upon the ground. Sometimes, especially in America, a better union between the earth and the ground is sought by ploughing the latter before commencing the embankment.

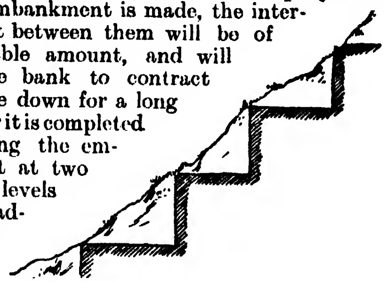
Fig. **14** shows a common way of forming an embankment on sidelong ground. The full lines show the form in which the earth was first tipped, and the dotted lines its ultimate shape. That part of the section numbered 1 was tipped first by means of a single tip-head, and this formed a toe to the main part of the embankment numbered 2, which was subsequently deposited by



14. COMMON METHOD OF MAKING EMBANKMENT FOR SIDELONG GROUND

means of a double tip-head. The bank is subsequently widened if necessary by side tipping, forming that part of the embankment numbered 3.

High Embankments. When the embankment to be formed is very high, say 30 or 40 ft., it is usual to tip it in two loads; this is of special importance when the excavation is effected by the help of a steam navvy. This machine, when working in stiff ground, brings out the earth in very large lumps, and when the waggons are emptied at the tip-head the largest lumps are those which roll down to the bottom of the slope. The embankment therefore advances upon a layer of very large lumps of soil, having a bulk of perhaps as much as 20 cub. ft. The higher the bank the thicker will be this layer of large lumps, and unless they are broken up by hand as the embankment is made, the interstices left between them will be of considerable amount, and will cause the bank to contract and settle down for a long time after it is completed. By tipping the embankment at two different levels this disadvantage is very considerably diminished.



13. STEPS FOR EMBANKMENT

The Act of Tipping. The act of tipping or emptying the contents of the waggon over the tip-head requires some description. The waggon, as has been described, comes forward towards the tip-head with the velocity it has acquired from the engine before the latter has been detached. As it comes forward, a loop of chain is allowed to trail behind it, and immediately before the waggon reaches the tip this chain is caught by a large hook placed between the rails for that purpose. The hook is attached to a hawser, the other end of which is anchored into the bank some way behind the tip. The object of this is to prevent the waggon from falling over the slope of the tip, as it would be liable to do if it reached it with an excess of velocity. The waggon is ordinarily checked by a number of sleepers piled up at the very extremity of the railway. On coming against these, the catches which fasten the body of the waggon to the frame are knocked up by the men at the tip-head, and then the forward velocity of the waggon is sufficient to cause the body to fall over and empty its contents down the slope. The men then pull the body back to its former position and refasten the catches.

Returning the Waggon. Sometimes the waggons are designed so that the body falls back of itself to its old position after its contents have been tipped out. The men must detach the hook from the trailing chain, and connect the waggon with the engine, which then comes forward to draw it away. The sleepers piled up at the tip-head to check the waggon have wrought-iron handles at each end to enable the men to move them about easily. They have to be constantly moved as the work of the embankment advances, and are placed contiguously on the earth where the rails end, so that the waggon runs upon them as it leaves the rails. The waggon, of course, is not allowed to leave the rail unless it can be helped; but the embankment, it must be remembered, is constantly advancing, and the rails cannot be advanced in very short lengths. The sleepers are therefore laid in an upward curve, where the rails end, bringing the waggon to a stop, and causing it to run back again upon the rails. The sleepers are cut up very rapidly and destroyed by the flanges of the wheels, but they may be protected by iron.

R. W. WESTERN

Richardson, Fielding, Smollett. Notable Novels and Women Novelists before Scott. A Further Study in English Prose Fiction.

THE NOVEL AND ITS CREATORS

Samuel Richardson. The "literature of the drawing-room," which Lyly began, was humanised by SAMUEL RICHARDSON (b. 1689; d. 1761), who may be called the father of the domestic novel. As a lad he was the confidant of the young women in the neighbourhood of his home in Derbyshire, the whereabouts of which, for some obscure reason, he successfully concealed. He read and wrote their love-letters for them, which accounts in some measure for his extraordinary success as a writer, chiefly for women, in the later years of his life. At the age of twoscore and ten, when he was a printer in Salisbury Court, Fleet Street, and possibly, it is suggested, after he had read Marivaux's "Vie de Marianne," as translated and continued by Mme. Riccoboni (1736), Richardson—who knew no language but English—was induced by two bookseller friends to take up the task of writing a book of "Familiar Letters on the Useful Concerns in Common Life." He was doubtless engaged in this work when he became acquainted with the story which inspired his first novel, "Pamela; or, Virtue Rewarded" (1740), although the latter was published several months before the "Familiar Letters." "Clarissa Harlowe" followed, in 1748, and "Sir Charles Grandison," in 1753. These three works form, as Professor Raleigh has remarked, a kind of trilogy, dealing respectively with humble, middle-class, and high life.

Richardson's Characteristics. Richardson's adoption of the epistolary style was at once condemned by Fielding, but, though Fielding's protest was well grounded, the method had its advantages, and is sometimes adopted even now. Perhaps the greatest obstacle in the way of a popular appreciation of Richardson today is his prolixity; and another drawback is his passion for moralising. Still, as Mr. Dobson says, he "must always find readers with the students of literature. He was the pioneer of a new movement; the first certified practitioner of sentiment; the English Columbus of the analytical novel of ordinary life. Before him, no one had essayed in this field to describe the birth and growth of a new impression, to show the ebb and flow of emotion in a mind distraught, to follow the progress of a passion, to dive so deeply into the human heart as to leave—in Scott's expressive words—'neither head, bay, nor inlet behind him until he had traced its surroundings, and laid it down in his chart, with all its minute sinuosities, its depths and shallows.' Added to this there was something in his nervous, high-strung, constitution—a feminine streak, as it were—which made him an unrivalled anatomist of female character."

To be perfectly frank, we find ourselves unable to urge Richardson upon the general reader. The abnormal length of his novels, their sluggish movement, their lack of real dramatic action, their mawkish sentimentality—these are defects enough to encourage the dust upon them. Let anyone who has not yet attempted to follow the adventures of "Pamela," one of the least attractive females in the whole realm of fiction, or the "impossible" story of "Clarissa Harlowe," or the soporific and interminable history of "Sir Charles Grandison," make the attempt and decide for himself. For the student of eighteenth century life, however, the novels of Richardson contain much that is invaluable, as the little printer could certainly observe and portray character as he saw it.

Henry Fielding. Richardson's relations to his great contemporaries were thus happily and humorously indicated by Andrew Lang: "Richardson was a woman's novelist, as Fielding was a man's. I sometimes think of Dr. Johnson's saying, 'Claret for boys, port for men,' and, smiling, 'brandy for heroes.' So one might fancy him saying, 'Richardson for women, Fielding for me, Smollett for ruffians,' though some of the latter writer's rough customers were heroes, too."

Two years after "Pamela" was issued there appeared "The History of the Adventures of Joseph Andrews and his Friend Abraham Adams, Written in Imitation of the Manner of Cervantes, Author of 'Don Quixote.'" In this work HENRY FIELDING (b. 1707; d. 1754), barrister, journalist, and playwright, essayed a satire and achieved a masterpiece, just as Cervantes himself had done. The Parson Adams of the story takes rank in the gallery of the heroes of English fiction with Goldsmith's Dr. Primrose—just as Sophie Western sits with the daughter of the Vicar of Wakefield. "The History of Tom Jones, a Foundling," appeared in 1749; "Amelia," in 1751. The "History of the Late Mr. Jonathan Wild the Great" was published among his "Miscellanies," in 1743. Thackeray, whose outlook on the world was similar to Fielding's, has said of him: "He may have low tastes, but not a mean mind; he admires with all his heart good and virtuous men, stoops to no flattery, bears no rancour, disdains all disloyal hearts, does his public duty uprightly, is fondly loved by his family, and dies at his work."

The Place of Fielding. As a literary artist, if not as a reader of the human heart, Fielding has a place above Richardson, and Sir Walter Scott styled him the "Father of the English Novel." He is a humorist, which Richardson is not. His knowledge of life is wide, his sympathies are catholic, his humour is of the

rarest vintage, his style is like the vigour of a spring morning, and his constructive faculty is classical. "There could," says Professor Raleigh, "be no better school for a novelist than is afforded by the study of Fielding's plots." Those who have read their Gibbon will not need to be reminded of the following tribute of the historian to the novelist: "The nobility of the Spensers has been illustrated and enriched by the trophies of Marlborough, but I exhort them to consider the 'Fairy Queene,' the most precious jewel in their coronet. Our immortal Fielding was of the younger branch of the Earls of Denbigh, who drew their origin from the Counts of Habsburgh, the lineal descendants of Eltrico, in the seventh century Duke of Alsace. Far different have been the fortunes of the English and German divisions of the family of Habsburgh; the former, the knights and sheriffs of Leicestershire, have slowly risen to the dignity of a peerage; the latter, the Emperors of Germany and the Kings of Spain, have threatened the liberties of the Old and invaded the treasures of the New World. The successors of Charles V. may disdain their brethren in England, but the romance of 'Tom Jones,' that exquisite picture of humour and manners, will outlive the Palace of the Escurial and the Imperial Eagle of Austria."

That is eloquent praise and not exaggerated. Fielding is securely a classic; his novels are as charged with life today as when they first won the admiration of his contemporaries. Dr. Johnson considered "Tom Jones" vicious, though he was fascinated by "Amelia"; but if the former great novel is too indulgent to the frailties of man, it is an open question whether it may not be so and yet rem in a work of sounder morality than Richardson's "Pamela," in which we are supposed to witness "virtue rewarded," but a brand of "virtue" that will not bear analysis. Fielding has created a crowded gallery of memorable characters—a true test of the novelist—and student and general reader alike must read him, though neither will need compulsion to the task.

Sterne. In addition to Fielding, three other novelists are included among Thackeray's representative humorists of the eighteenth century. In the case of LAURENCE STERNE (b. 1713; d. 1768), however, a distinction is made with which most modern readers will agree. The distinction is that Sterne is a great jester rather than a great humorist. "He fatigues me with his perpetual disquiet and his uneasy appeals to my risible or sentimental faculties. He is always looking in my face, watching his effect, uncertain whether I think him an impostor or not; posture-making, coaxing, and imploring me." The author of "The Life and Opinions of Tristram Shandy, Gent." (1759–1767), and "A Sentimental Journey through France and Italy" (1765) owed much, doubtless, to an acquaintance with the works of Rabelais and Cervantes and Burton's "Anatomy of Melancholy" (1621), but, as Mr. Birrell has said, "Sterne is our best example of the plagiarist whom none dare make ashamed." Careless, usually, of his grammar, he can on occasion find the "only word." He is ribald, but not salacious. As a sentimentalist, he may be—he is—tedious and tiresome. His morals may be bad, but one doubts with Coleridge if they can do much more harm to anyone who was not bad enough before.

Smollett. "The Hogarth of English Letters" is a phrase applied to TOBIAS SMOLLETT (b. 1721; d. 1771). Like Fielding, Smollett commands respect because he was a hard worker. He had "the very deuce" of a temper, maybe, but he sustained many hard, unkindly blows of ill-fortune. He was a stout and manly hearted Scotsman. Professor Masson includes "The Adventures of Roderick Random" (1748), "The Adventures of Peregrine Pickle" (1751), and "The Expedition of Humphrey Clinker" (1771) with "Joseph Andrews" and "Tom Jones" as "novels as nearly as amusing as any we have." In them, he says, "for the first time British literature possessed compositions making any approach, in breadth, bustle, and variety of interest, to that form of literature, always theoretically possible, and of which other countries had already had specimens in 'Don Quixote' and 'Gil Blas'—the comic prose epic of contemporary life." In the novels of Fielding and Smollett is represented the kaleidoscope of life, whereas Richardson keeps the attention more intimate with the feelings of his chief characters. One of Smollett's assets is his Scotticism; and though "Roderick Random" and "Peregrine Pickle" should cease to be read, Scotsmen, in the opinion of Professor Masson, "would still have an interest in preserving 'Humphrey Clinker.'" Like Fielding and Sterne, Smollett was a creator of types, but his own life affords a singular contrast to that led by some of his literary creations.

Goldsmith. Of OLIVER GOLDSMITH (b. 1728; d. 1774) it has been said that *Virginibus puerisque* might have been his appropriate and uncontested motto. His one novel, "The Vicar of Wakefield," written though it was with a moral motive akin to that which induced Richardson to write "Pamela," is a work that stands alone. "There are a hundred faults in the thing," says the author in his preface. but, as it has been wittily observed, a hundred things might plausibly be said to prove them beauties. The "charming prose idyll of dear Irish Goldy" may be described as both highly improbable and as intimately true to nature.

Written in 1761, "The Vicar of Wakefield" was not published till 1766. Professor Raleigh, who cites its admirable comedy as perhaps its highest merit, makes a very striking comment in his reference to this work: "The story of its discovery by Johnson, as told in Boswell, is one of the best known and most characteristic passages of Goldsmith's life. The picture of Goldsmith, arrested for debt, changing the guinea sent him by his friend for a bottle of Madeira, helpless and angry, while a completed novel, which sold at the first offer for sixty pounds, lay written in his desk, has often been employed to illustrate the improvidence of authors. It might

be better used to illustrate the prudence of an author who was an improvident man. No one ever drew a firmer line between the works he wrote to last and the compilations that his necessities extorted from him than was consistently drawn throughout his life by Oliver Goldsmith. It did not occur to him to expect fame from his histories, political or natural . . . As little did it occur to him to treat his carefully wrought original works as so much merchandise, or a sop for the bailiff, and perhaps Johnson's kindly offices prevented 'The Vicar of Wakefield' from receiving its full share of the correction and polish that Goldsmith bestowed on all his best work."

Minor Novels before "Waverley." Among the other novels which preceded "Waverley" (1814) must be named "The Adventures of David Simple," by SARAH FIELDING (b. 1710; d. 1768), the sister of the author of "Tom Jones"; "The Female Quixote" of CHARLOTTE LENNOX (b. 1720; d. 1804); "The History of Rasselas, Prince of Abyssinia," which JOHNSON wrote in 1759, partly to pay for his mother's funeral and partly in answer to the witty libertinism of Voltaire's "Candide"; the "Arundel" and "Henry" of RICHARD CUMBERLAND (b. 1732; d. 1811), an imitator of Fielding; "Chrysal; or, the Adventures of a Guinea," by CHARLES JOHNSTONE (b. 1719? d. 1800?), whose vein was chiefly satirical, and whose quarry was political and domestic vice; "The Man of Feeling" and "Julia de Roubigné" by HENRY MACKENZIE (b. 1745; d. 1831), a follower of the sentimental methods of Sterne; "The Castle of Otranto," a "Gothic Romance," by HORACE WALPOLE (b. 1717; d. 1797), who, as Professor Masson says, did something to remind British readers that "there had been a time in the world when men lived in castles, believed in the devil, and did not take snuff or wear powdered wigs"; "The Old English Baron" of CLARA REEVE (b. 1729; d. 1807), whose crude style succeeded where that of Walpole failed; "The Romance of the Forest," "The Mysteries of Udolpho," and "The Italian" of ANN RADCLIFFE (b. 1729; d. 1807), the originator of the mysterious and fascinating blackguard in fiction—a truly Protean creation; "Hermsprong; or, the Man as He is Not" by ROBERT BAGE (b. 1728; d. 1801); "The Monk" of MATTHEW GREGORY LEWIS (b. 1773; d. 1819); the "Zeluco" of Dr. JOHN MOORE (b. 1729; d. 1802); the "Vathek" of WILLIAM BECKFORD (b. 1759; d. 1844); the "Caleb Williams" and "Fleetwood" of WILLIAM GODWIN (b. 1756; d. 1836), one of the first English writers to utilise the novel for political purposes; "A Simple Story" and "Nature and Art" by Mrs. INCHBALD (b. 1753; d. 1821); the "Old Manor House" of CHARLOTTE SMITH (b. 1749; d. 1806); "The Fatal Revenge" and "Melmoth the Wanderer," by CHARLES ROBERT MATURIN (b. 1782; d. 1824), who possessed an almost uncanny power over the treatment of the supernatural; "Adeline Mowbray," by Mrs. OPIE (b. 1769; d. 1853); the "Children of the Abbey" of REGINA MARIA ROCHE (b. 1764? d. 1845); and last, but not least, the "Rosamund Gray" of CHARLES LAMB (b. 1775; d. 1834).

There is scarcely a novel we have named that is not worthy of the attention of the student, not always for its own sake but as a contribution to the growth of English fiction.

Four Great Women Novelists. Before "Waverley" was published, four lady novelists had written works which attained a higher level as novels than perhaps any named in the above group. FANNY BURNEY, Madame D'ARBLAY (b. 1752; d. 1840), in "Evelina" and "Cecilia," had treated character with all the realism of Ben Jonson without the coarseness of that writer's dramatic "humours." To quote Mr. Austin Dobson, "'Evelina' marks a definite deviation in the progress of the national fiction. Leaving Fielding's breezy and bustling highway, leaving the analytic hothouse of Richardson, it carries the novel of manners into domestic life, and prepares the way for Miss Edgeworth and the exquisite parlour pieces of Miss Austen."

MARIA EDGEWORTH (b. 1767; d. 1849), whose delightful character finds eloquent expression in "Castle Rackrent" applied in her work a needed corrective to the passion for the weird and horrible romances which Mrs. Radcliffe, "Monk" Lewis, and others had made so popular, but which was to be aroused again in 1817 by the "Frankenstein" of Mary Shelley. Miss Edgeworth's Irish tales inspired the patriotic novels of Sir Walter Scott.

The Genius of Jane Austen. JANE AUSTEN (b. 1775; d. 1817) wrote six memorable novels—"Sense and Sensibility" (1811), "Pride and Prejudice" (1812), "Mansfield Park" (1814), "Emma" (1816), "Northanger Abbey" (1818), and "Persuasion" (1818)—all of which, together with Fanny Burney's "Evelina" and "Cecilia," are frequently reprinted today. Macaulay suggested, Professor Goldwin Smith has adopted, and Profesor Raleigh looks favourably upon, a comparison between Jane Austen and Shakespeare. This is derived partly from the absolutely impersonal character of her works. She tells us nothing about herself, and she is oblivious of the happenings in the great world beyond her own circle. She is a satirist minus indignation; hers is the quiet irony of the cultured mind; her subtle humour is only audible to the cultured ear. To study her books is to be given a series of invaluable lessons in the art of observation and in precision of detail. Miss Austen's method was appreciated by Scott. "The big bow-wow strain I can do myself, like any now going," said Sir Walter "but the exquisite touch which renders ordinary commonplace things and characters interesting from the truth of the description and the sentiment is denied me." Miss Austen supplies a faithful picture of the English country life of her period.

JANE PORTER (b. 1776; d. 1850) wrote two novels that still retain a certain measure of popularity, "Thaddeus of Warsaw" (1803) and "The Scottish Chiefs" (1810). Both are eminently readable; and they entered a field which so far had been untrodden, the field of historical romance.

J. A. HAMMERTON

Clerical and Operative Posts in the Navy Department. The Coastguard Service. Customs and Excise Officers. The Government Laboratory.

ADMIRALTY AND REVENUE POSTS

Assistant Clerks in the Navy. Youths who covet a sea life, but who are not able to undergo the long, expensive training exacted of budding naval officers, should turn their attention to the limited competitions for assistant clerkships in the Navy, admitting to the well-paid and attractive calling of naval paymaster. Probably, because the advantages of this service are not as well known as they deserve to be, the competition for vacancies is not very severe, and the entrance examination offers no serious obstacle to a well-educated lad with a fair knowledge either of three foreign languages or of two languages and the elements of natural science.

Many would-be competitors are discouraged from entering by the fact that a nomination is requisite for these appointments. But this difficulty is more apparent than real, as private influence with the naval authorities is not imperative to secure the right to compete. A nomination by the First Lord of the Admiralty is readily granted to suitable candidates. Application should be made to his private secretary as soon as the lad for whom it is sought reaches the age of 16. The contests are held each June and December for between 20 and 30 vacancies, and candidates must be between 17 and 18 years old on the 15th of the following July or January (as the case may be). They must also be well developed and active for their age, and physically suited in all respects for service in the Navy. Short sight will not necessarily disqualify those who are otherwise fit.

The character of the entrance examination is shown by our schedule of subjects and marks, which relates to a competition for 20 places lately attended by 70 aspirants.

A note may be added on these subjects. Mathematics consists of algebra, geometry, and trigonometry; the test in English includes précis and shorthand (the latter being of special importance); and the English history paper has particular reference to the period since 1485. In modern languages special attention is given to the oral examination, and the language not offered as obligatory may be taken as an optional subject. The science papers relate to mechanics, heat, physics, and inorganic chemistry, and include practical tests. Certificate "A," obtainable in the Officers' Training Corps, entitles its holder to an extra 50 marks in the examination.

Successful candidates are appointed as assistant clerks at 2s. 6d. a day, and while in that grade must be furnished by their parents or guardians with an allowance of £20 a year. After a year's service, and on passing a further examination, they are rated as clerks at 4s. a day. Their further prospects may be judged from statistics of annual salaries in the Service:

Assistant clerks, £45 12s. 6d.; clerks, £73; assistant paymasters, £91 5s. to £209 17s. 6d.; paymasters (in three classes), £255 10s. to £602 5s.; paymasters-in-chief, £693 10s.

Speedy promotion is assured, at least to the grade of junior paymaster, for an officer whose conduct and abilities are satisfactory. On entering that grade a heavy outlay is necessary, the cost of uniform and other gear being about £100. But with this exception the rates of pay are high enough to render him self-supporting after the first year of his sea service—a great advantage to candidates whose relatives are not wealthy.

It need only be added that the sea life is a pleasant and varied one, and that the paymaster's post is generally regarded as the easiest berth in the ship.

Dockyard Apprentices. The various ratings of the combatant service afloat are discussed in those chapters of this group which are devoted to the ARMY, NAVY, and MERCHANT SERVICE. Mention must be made here of a number of good openings in the land service, by means of which an intelligent lad between the ages of 14 and 16 may secure a thorough training in the naval workshops, and eventually the wages of a skilled artificer at least.

EXAMINATION FOR ASSISTANT CLERKS IN THE NAVY

Order of Merit	Obligatory						Optional: Any two may be taken.				Total
					Alternative.						
	Arithmetic.	Mathematics.	English (Handwriting, Composition, etc.).	Geography and English History.	French.	German.	Latin.	Greek.	Elementary Science.	German or French.	
Maximum	500	600	700	400	600	600	600	600	600	600	4000
No. 1 ..	320	331	384	252	—	529	480	—	—	401	2697
No. 20 ..	365	304	404	190	462	—	305	130	—	—	2160

Open competitions for 400 to 500 dockyard apprentices are held in May of each year, and are attended by some 1500 candidates. The subjects of examination are English (writing, spelling, composition, and questions on a work of fiction), arithmetic, mathematics, elementary science, history and geography, and freehand drawing. The lads who do best in these papers must pass a strict test in eyesight, hearing, and general health. They are then bound by indenture to serve for six years as apprentices to one or other of the dockyard "trades," such as that of shipwright, engine-fitter, or smith. No premium is required, and while learning their trade the apprentices receive weekly wages, which begin at 4s. and rise by 2s. each year to 15s. They are required to attend the dockyard school three or four times a week for a year at least. The best of them are kept on as scholars for three or four years, and are then examined in scientific and technical knowledge. A shipwright apprentice who distinguishes himself at this test is given a golden opportunity in the shape of a cadetship in naval construction.

Other apprentices, on completing their six years' indenture, are engaged for two years as journeymen, at rates of pay ranging from 29s. a week upwards, according to their trade and the skill they have gained in it. They are then qualified for permanent posts, with wages varying between 35s. and 45s.; and for promotion to the rank of foreman and to other responsible positions.

Naval Constructors. More fortunate is the ex-apprentice who wins a cadetship in naval construction. After two or three years' further training, he is likely to be made an assistant naval constructor. In this capacity, while still a youth, he is employed in the important work of designing and building naval vessels. His salary is £200 a year, rising to £400, and he has a sure prospect of £650, with many chances beyond. At least three directors of naval construction, with salaries of £1800 a year, have risen from the grade of dockyard apprentice.

Writers and Others. The clerical staff of the Admiralty includes a number of subordinate officers, known as hired writers and boy writers, who are employed in the dockyards and naval establishments. The ranks of the boy writers are recruited in part from applicants trained for the Service at Greenwich Schools, partly by competitive examinations in simple English subjects, shorthand, bookkeeping, and general knowledge, held yearly in London and at the chief naval posts.

Candidates for boy writerships must be between the ages of 14 and 17, and of sound constitution. If successful, they are appointed at 9s. a week, and receive a 3s. rise each year, to the maximum of 18s. During their service they must attend the dockyard school for two evenings a week for about three years, in order to fit themselves for adult employment. At the age of 19 a boy writer is eligible for promotion to the grade of hired writer, and, if he has taken advantage of the free training provided by the Admiralty, he should have no difficulty in getting recommended for this permanent post. He then receives 24s. a week, with a yearly advance of 1s. 6d. to 36s., and has excellent chances of winning a dockyard clerkship of the third grade. This step ensures him 51s. weekly at least, and may lead to a first-grade clerkship, rising to £250 or £300 a year. Thus, for a steady and intelligent lad who must earn his own living from an early age, a boy writership is an easy avenue to permanent work which is better paid than in the commercial world.

For men writerships in the naval service afloat, open competitions are held at Chatham, Portsmouth, Devonport and Queenstown each May and November. The age limits are 18 and 23, and the examination subjects comprise English, commercial arithmetic, typewriting, and shorthand, marks being also given for "general smartness and knowledge." Successful candidates enter the Navy for twelve years, and are paid 14s. a week, with free rations, as third writers. For the next grade the pay is 21s., and for the first writers, who rank as petty officers, it is 28s. a week. There are further openings for able men as chief writers at 35s. to 38s. 6d.—always with free rations; and promotion may be won to warrant rank, with pay ranging from £127 to £182 a year. Particulars of third writers' examinations can be obtained gratis from the Secretary to the Admiralty, Whitehall, S.W.

The Civil side of the Admiralty may be completed by a few words on the conditions of entry and rates of pay which obtain in the Coastguard Service.

Coastguard Service. Seamen of good character who have completed nine years' continuous service, and are recommended by their captains, are eligible for admission to the Coastguard under the following conditions. They must be trained men or holders of a torpedo or gunnery rating, not over 37 years of age, able to swim and to read and write, and willing to

RATES OF PAY AND ALLOWANCES FOR COASTGUARD SERVICE

No.	Rating.	Pay. £	s.	d.	Provision Allowance. £	s.	d.	Other Emoluments.
185	Divisional Chief Officers	182	10	0	24	6	8	Allowance for Quarters.
	Chief Officers	109	10	0				
	,, rising in 10 years to	146	0	0				
2803	Chief Petty Officers	57	15	10				Free Quarters.
	Petty Officers	39	10	10				
	,, after 4 years	44	2	1				
	Leading Boatmen ..	31	18	9				
	Boatmen	28	17	11				
2988								

Good-conduct badges, 1d. a day for each badge. Boatmen, 1d. a day when qualified as trained men

re-engage, if necessary, for continuous service to complete their time for a pension. A limited number of stokers of eight years' service are also admitted.

Coastguard men are liable to be embarked in turn for such cruises as the Admiralty may appoint, and, if found unfit for active service at sea, may be discharged with a pension or gratuity, according to the length of their service. Otherwise they are retained until the age of 50, or, in the case of chief petty officers, until 55, when they retire on a life pension.

Apart from the commissioned officers, who number only 83, the strength, ratings, pay, and allowances of the Coastguard Service are as stated in the table on page 2574. Modest as are the rates of pay in themselves, it must be remembered that the provision of free quarters is a valuable one, and that, with this advantage and a liberal allowance for rations, the coastguard's needs are small.

Customs and Excise. No more interesting duties are comprised in the service of the State than those which relate to the safeguarding of the vast revenues derived from taxation. The bulk of these revenues, apart from income-tax and stamp and legacy duties, is derived from two main sources—Excise charges and Customs dues. The former consist largely of fees for trading and other licences and the duties payable in respect of the manufacture of beer and spirits. Customs work, on the other hand, is mainly the enforcement of taxes upon imports, including the prevention of smuggling. It will be readily understood that the two branches have much in common; and in 1909 the two separate branches to which the collection of these revenues had formerly been entrusted were welded into a single huge revenue department, the Board of Customs and Excise.

A characteristic feature of this service is that, in addition to a large indoors staff of Class I. and subordinate clerks, it employs a great many executive officers, whose duties, while often arduous, afford plenty of variety and interest, and for the most part are performed in the open air. This outdoor staff, instead of being restricted to London like the majority of national servants, is scattered throughout the kingdom, and is subject to frequent transference from district to district. Hence, the executive service of the Customs and Excise attracts every year a number of hardy young fellows who prefer hard work, irregular hours, and change of surroundings to the monotony and restraint of a life spent at a London desk.

Outdoor Officers. The outdoor establishment of the Customs and Excise is divided into two branches—the general service staff, recruited by open competition, and the waterguard and preventive staff, a subordinate service whose members enter without competition.

Officers of Customs and Excise. From 200 to 300 appointments of this class are filled every year by means of competitions—usually held in March and November—that are open to all unmarried men between 19 and 21 years of age who satisfy the prescribed conditions as to health and physique. As is imperative in a service of this character, any serious defect of vision is regarded by the authorities as a disqualification. The age of candidates is reckoned in the following way: At an examination held in the first half of the year they must be of the prescribed age on March 1, and at one held in the second half-year they must be of the prescribed age on September 1.

EXAMINATION FOR CUSTOMS AND EXCISE OFFICERS

Order of Merit.	Service Marks.	Handwriting.	English.	Arithmetic.	Science.	Two only. French.	German.	Latin.	Mathematics.	Bookkeeping and Shorthand.	History and Geography.	Total
Max.	96	300	600	600	500	500	500	500	500	500	500	3000
1	96	272	416	496	358	426	—	—	420	—	—	2484
75	—	300	362	396	383	—	—	—	310	—	358	2109

A clear idea of the character of the educational contests may be gained from the table given above. It shows the marks obtained by the highest and lowest successful candidates at a recent competition, which was attended by 1086 students.

There are no obligatory subjects, but the competition is so keen that—as our table shows—good marks in every paper that the regulations allow to be taken are absolutely essential for success. Candidates who have served as boy clerks now receive service marks at these contests.

In these examinations, English comprises essay-writing and a précis of printed documents. The science test is theoretical only, questions being set in the elements of physics and of chemistry. Mathematics includes the use of logarithms, and in the modern languages composition is required, as well as translation from and into English. Special regions are prescribed for the geography paper, and a special period for the English history. The shorthand examination consists of taking down

three passages at the respective rates of 60, 80, and 100 words a minute, and afterwards transcribing the shorthand note into longhand. A printed syllabus, showing in some detail the scope of the examination, may be obtained (gratis) from the Civil Service Commission, Burlington Gardens, W.

Salaries and Duties. An officer of Customs and Excise is liable to serve at any port or station in the kingdom. The official regulations prescribe that "during the early years of his service an officer will be liable to constant change of station, and will have no fixed residence." And, throughout his service, promotion may mean removal to a new district —possibly from Land's End to John o' Groat's.

The salary is £80 a year on appointment, advancing by £7 10s. annually to £160, and thence by £10 to £300. When an officer attains £160, and again at £250, he must pass what is quaintly called an "efficiency bar." That is, before obtaining a further increment he must receive a favourable report from his superiors as to the way in which his books are kept, and also as to his character.

For the next grade—that of surveyor—competitive examinations in practical subjects connected with departmental duties are held at stated intervals. The salary of a surveyor is £320, rising by £15 yearly to £450, with an efficiency bar at £400. Promotion to the rank of inspector and collector (£500 by £20 to £650, with prospects of £800 and upwards) is made by merit; but as, in comparison with the numbers of officers and surveyors, these positions are very few, some good fortune as well as marked ability is needed to gain one of them.

THE ADMIRALTY

The hours of attendance are 48 weekly, any overtime being paid for at special rates. Officers employed on quay duties wear a peaked cap and a blue serge suit. No other officers are required to wear uniform of any sort.

Customs work is manifold, interesting, and sometimes exciting. It includes boarding vessels, the examination of baggage, the collection of light dues, dock and warehouse work in connection with dutiable imported goods, and many other duties afloat and ashore. Changes of station are frequent, and there is a good deal of night work and extra duty, for which special remuneration is paid.

The Excise service also involves a great variety and range of work, a busy town station differing widely in its duties from those of a quiet country district. Generally they include bonded warehouse supervision, the collection of licence duties, distillery survey, brewery survey, and inquiries under the Old Age Pension Acts and in connection with National Health Insurance. In either branch of the department, an officer's work is done, for the most part, without supervision, combining a good deal of liberty with serious responsibility. Hence the importance attached by the authorities to the way in which the officers' books and records are kept. Despite its occasional hardships, men of active, self-reliant temperament find the life of a Customs and Excise officer pleasant enough.

The Preventive Service. This branch is occupied with less responsible and technical duties, and offers far fewer chances of advancement than the general service section. Recruits were formerly enrolled as Customs boatmen, but now are termed Preventive Men. The service is now recruited by means of an examination, for which candidates are nominated by the Board of Customs and Excise. Candidates must be between 17 and 20 years of age, at least 5 ft. 4 in. in stature, and 32 in. round the chest; or, if the height is greater than the minimum, the chest measurement must be proportionate. They are required to pass a qualifying examination of the simplest character in reading, writing, and elementary arithmetic.

Preventive men start at 18s. a week, rising by 1s. 6d. annually to 33s. On promotion to the grade of preventive officer, this salary becomes £115 a year, with £5 increments to £150, and thence by £7 10s. to £200. There are also a few higher posts, with salaries ranging up to £650.

The Government Laboratory. Originally a small branch of the Inland Revenue Office, this laboratory has become so useful and has grown so rapidly in recent years that in 1911 it was made a separate department under the Government Chemist. Its staff is occupied very largely in analysing various samples of dutiable goods, and of milk, butter, and other articles of food, as well as drugs, in which adulteration or improper dilution is suspected. In addition to a permanent staff, the Government Laboratory employs some 70 temporary assistants. A number of these latter are Customs and Excise officers who have been selected by their superiors for the post. Some of them receive an extra allowance of £20 a year while attending there. The training afforded by the laboratory is a valuable one, and the most promising among the temporary assistants are nominated by the head of the department to compete for vacancies in the permanent staff of analysts. These officials are paid £160 a year, rising by £15 annually to £350, and on promotion to the first class advance £20 yearly from £400 to £550. There are higher posts obtainable, and a footing on the temporary staff of the Government Laboratory may afford to a young member of the Customs and Excise who possesses the requisite ability and aptitude for science the first step in a very successful career pursued under highly interesting conditions.

ERNEST A. CARR

The Nature of Genetic Factors. The Phenomenon of Segregation. The Practical Value of Mendelism.

THE MEANING OF MENDEL'S LAW

The reason for the double Mendelian formula required for any individual, in any respect, is evident from the concluding remarks in our last chapter, and we see how, in any such respect, there are two possible kinds of pure-bred individuals, and one kind of cross-bred. And as we regard the dominant as due to something present, and the recessive as simply the absence of that something, the time has come when we may ask what that something actually is which has such immense and permanent consequences in the individual formed from the germ-cell that contains it. It has hitherto been called a "factor," and the term is a good one, for it expresses the significance of the thing—that it makes something, but expresses no opinion as to its nature. Now, we have already made some study of germ-cells with the microscope, and have noticed their nuclei, the fashion in which dyeing differentiates the parts of the nucleus, and the further fashion in which the stainable parts of the nucleus break up into a fixed number of particles or chromosomes at certain stages in its life-history. Also, we have noticed the centrosome, which lies near the nucleus. Can we assert any correspondence between certain Mendelian "factors," the things which cause the appearance of such-and-such features in the individual, and, for instance, the chromosomes or the centrosome?

A Link between Factors and Chromosomes. Possibly, to some slight though interesting extent, we can. The chance of discovery here is hopeful, and the modern microscope is being most earnestly employed, so as to connect the facts of cytology, above all the cytology of germ-cells, with the facts of genetics. In some instances it may be the case that the germ-cell which is destined to give rise, when mated, to a female individual contains an extra or "accessory chromosome," and we might suppose that this accessory chromosome is the factor, or bears the factor, that produces femaleness. Up to the present these appear to be the nearest approach to definite results in this field. Even so, there are elements of doubt. On the other hand, though this theory of the accessory chromosome should be established, and though a few more similar cases should be established, it is obvious and certain, and immensely disconcerting in a sense, that no microscopic study will ever reveal in the germ-cells of any species a tithe or a ten-thousandth part of the detail required to account for the characters of the mature individual. If the accessory chromosome, found in some of the germ-cells of some species, be the factor for femaleness, it is the rarest exception in having any visible form at all. The overwhelming majority of factors cannot be anatomical features of the germ-cell at all, whatever they are. Clearly we must pierce to an obscurer order of things. We must penetrate from anatomy, however microscopic, to chemistry; from structures or tissues to the molecules which compose them. Here the student who remembers the second chapter of this course will begin to guess rightly. There it was observed how important are ferments in life, that we digest and breathe by them, that "life is a series of fermentations," from the physical aspect, and even that we develop from germ-cells by fermentations. Development, in short, is itself a series of fermentations, and we may guess that the factors in the germ-cells must also be ferments.

Changes Wrought by Ferments. That this is an approximation to the truth we become certain when we analyse numerous instances of the inheritance of colour. The chemist analyses the colour of a petal in a given case, and notes that if the pigment be oxidised it becomes a pigment of another colour; or it may be the other way about—that is, a certain pigment, when reduced—a technical term familiar to the student of the course on Chemistry—yields another pigment. The difference between a white flower and a purple one may be thus shown to depend upon no more than the absence or presence of a simple ferment which would oxidise the white pigment and turn it purple. Scores and hundreds of such cases are known. The oxidations and reductions required to make such differences are typically the result of ferments—for those are just the simple processes which innumerable known ferments induce. We may well hesitate if we are asked to believe that the difference between a normal and a defective human brain of a certain type is similarly due to the presence of a ferment which makes the "dominant factor" for the normal brain. But we need not hesitate when the case involved is demonstrably no more than a simple oxidation change in an identifiable and isolable pigment in the petals of a plant or the skin of an animal.

In yet other cases it seems that the difference between the dominant and recessive does not depend upon a ferment, which is present in each case, but that in the former there is present some definite chemical substance for the ferment to act upon, and in the recessive that substance is not formed.

The Nature of Genetic Factors. However, the case cannot be nearly so simple as we have hitherto suggested, and the student must beware of supposing that any authority on this subject declares the genetic factors to be ferments. The real nature of the contents of the germ-cell and of the factors that it comprises

must be vastly more subtle than that. There is no room in the germ-cell for the sheer quantity of ferments that would be required. As Bateson says, "The thing transmitted can only be the power or faculty to produce the ferment."

In the first place, we know by a host of cases that ferments do not exist in the living body as such. There is no pepsin in the stomach cells, no blood-clotting ferment in the blood. What we find are substances which are capable of being transformed into ferments *when they are needed*, but not till then. The process may be practically instantaneous, as in the formation of the blood-clotting or "fibrin-ferment" when a blood-vessel is injured; but there is all the difference in the world, the difference between life and death, between the facts as they are, and the existence of the fibrin-ferment as such in the blood—which would immediately become solid. Therefore we recognise the existence of what are called *pro-ferments*—bodies which have no fermentative power as they are, but which are capable, under certain conditions, of becoming "activated," as the chemists term it, and then doing wonders.

The genetic factors in the gametes cannot even, however, be pro-ferments, though doubtless pro-ferments and, in the course of development, active ferments may be found in the gametes and the products of their division. To substitute the idea of pro-ferments for that of actual ferments is only to recognise a stage which is of no ultimate importance. We have to account for the origin of these pro-ferments, and for the power which calls them into being. And it is immensely significant for our ultimate theory of the nature of Life that Professor Bateson himself, who is sternly opposed to any but the mechanical explanation of these problems, and who looks upon any other as "mysticism," should be found writing that "the thing transmitted can only be the power or faculty to produce the ferment." Have we not here already left the realm of the material, and begun, perhaps unconsciously, to recognise the presence of something of which the material is merely an instrument? So much, alone, can we say here as to the nature of genetic factors—which the reader will see to be a question involving the very ultimates of the vital problem.

The Analysis of an Individual. Whatever the factors be, we have next to consider how they are distributed to or in the germ-cells which are formed by the individual we are discussing. He—or she—the product of two germ-cells and their factors, in turn produces, or houses the production of, a vast multitude, thousands or millions, of germ-cells or gametes. Already we have learnt, from the facts of Mendel's first experiment, how to state what follows, wherever the factor in question is Mendelian. The student must particularly note that, as each individual is double, formed from two gametes, so each gamete is single.

As we need to rule two columns for our list of ingredients in the individual, so we need one column only for each of his gametes. Two such columns, corresponding to two gametes, will then represent the double individual they go to form. Now, in the case of the pure tall or short peas, D D or R R, the gametes are, each and all, D or R respectively. The surprising discovery of Mendel applies to the case of the D R, or impure dominant. The gametes of such an individual, on Bateson's hypothesis, "do either contain or not contain a representation of the ingredient, just as the original gametes did or did not contain it." Further, the chances are equal in each case; so that, on the average, half the gametes are D and half are R.

This is the fact of segregation, which we have already asserted to account for Mendel's law, but which we have yet to explain—if we can. At least we have found a definite feature of the germ-cells which explains the fact that the character we are discussing is one of those which *mendelise*—as we now often say.

The Process of Segregation. But how are we to explain Mendelian segregation? The presence and absence hypothesis has already helped us very really, but it is far from carrying us all the way. Here is its author's attempt to represent to the mind's eye what, on this hypothesis, must in some fashion or other happen in segregation.

"So, recurring to the simile of the man as made by the mixing of tinctures, the process of redistribution of his characters among the germ-cells may be represented as a sorting back of the tinctures again into a double row of bottles, a pair corresponding to each ingredient, and each of the germ-cells as then made of a drop from one or other bottle of each pair: and in our model we may represent the phenomenon of segregation in a crude way by supposing that the bottles having no tincture in them, instead of being empty, contained an inoperative fluid, say water, with which the tincture would not mix. When the new germ-cells are formed, the two fluids, instead of diluting each other, simply separate again. It is this fact which entitles us to speak of the purity of germ-cells. They are pure in the possession of an ingredient, or in not possessing it; and the ingredients, or factors, as we generally call them, are units because they are so treated in the process of formation of the new gametes, and because they come out of the process of segregation in the same condition as they went in at fertilisation."

Consider now a definite character, say brownness of eye, or the peculiarity of being unable to see in a dim light, which is known as night-blindness. Studying a pedigree, we observe that this character appears in certain individuals but not in others. Is it a dominant or a recessive? And conversely, is the blue eye, or the normally seeing eye, dominant or recessive? The pedigree will tell us how to tell a dominant from a recessive. In the case of night-blindness, where one family has been recorded for ten generations, extending over centuries, on both sides of the Atlantic, we notice that the children of the unaffected are always also unaffected. The affected, mating with normal persons, have families comprising affected and unaffected children. Clearly night-blindness is a dominant.

Breeding Out a Family Taint. And now we begin to see the practical value of Mendelism. Suppose we do *not* want a certain character in a rose, a horse, a baby. An individual comes into being from a stock notoriously affected with the character we dislike. This individual is without it; what will its offspring be? Will the undesired feature "skip a generation" and return? Or may we say that, notwithstanding the deplorable family history, the offspring of this individual will be as free from the family taint as those of any other?

Without the Mendelian key the practical breeder, the actuary, the eugenist—as we shall later see—were helpless in such a case. They could only argue that characters *do* turn up again in the offspring of unaffected individuals of affected stocks, and that such individuals were best left aside for breeding purposes. But, in the case of all characters which have been proved to mendelise, the problem is now soluble.

First we look to the records, and note whether the character is a dominant or a recessive. If it be a dominant, it will reappear in the offspring of individuals possessing it, in various proportions which we have already studied, according to the particular parental combination in question, but those offspring in whom it does not appear are free from it, individually and racially, so far as we know, for ever. Thus, should any or all the unaffected members of the night-blind family marry, but none of the others, the malady will come to an end; and thus also, in eugenics and its ethics, we can relieve the mind, approve the marriage, and welcome the offspring of all the unaffected members of gravely affected stocks, where the undesirable character is a dominant. The immense practical importance of such a discovery as this can scarcely be overstated.

The Marriage of Cousins. On the other hand, the undesired character may be a recessive. It follows that, according to the constitution of the parents, *normal* offspring may be *impure* dominants, carrying the recessive character in half their germ-cells. The prejudice against cousin marriages merely means that if, and only if, the stock be affected, the marriage of personally normal cousins may be really the marriage of two impure dominants in this respect, and we may therefore expect one child in four to display the family failing.

But on the other hand, if the recessive character be a desirable one, such a cousin-marriage may yield one child in four possessing the welcome character, though neither parent had it—if each was an impure dominant. Does not this throw an entirely new light upon the problem of the marriage of relations? At once we see that the simplest and truest answer to inquiries as to the consequences of marriages between cousins is that which the present writer has returned to correspondents for many years—"It depends upon the cousins." Here let another fact be noted which has been purposely illustrated in the foregoing paragraphs.

Characteristics Determined Only by Breeding. It is that we can never say of any characteristic of any plant, animal, or human being, whether normal or morbid, whether usual or unusual, whether unusual and undesirable or unusual and desirable, that it is a dominant or a recessive until we have made the breeding experiments necessary, or have studied an adequate pedigree, which comes to the same thing. Night-blindness, for instance, happens to be a dominant. So are scores of other morbid conditions of the eyes and skin. But various types of nervous disease are found to be recessives, and so is musical faculty in the opinion of some recent inquirers into the subject.

Again, in the case of the white petals of a flower, no one can say whether the whiteness is dominant or recessive until the test has been made. We know cases where the white is dominant over some colour, and is due to the presence of a factor which turns that colour white. We know cases where the white is recessive, and due to the absence of some pigment-forming factor. Nay, we know cases where white is dominant, and due to the presence of a factor which *inhibits* the formation of the colour that would be produced without it.

The Significance of Mendel's Discovery. We must absolutely clear our minds, therefore, of any assumption that dominant and recessive have anything to do with desirable or undesirable, normal, abnormal, or morbid characters. Each case, in every species, has to be worked out empirically at present, and dealt with according to the result found, when we are trying to create new types by breeding. Some day, doubtless, a law in these matters will appear. Doubtless it means something that, in our own species, unfortunate peculiarities of the eye and skin are usually dominants, and those of the nervous system usually recessive; and if a *fortunate* nervous peculiarity like musical faculty be also recessive, there is another lesson for us as to the entire indifference of dominant and recessive to any of our criteria.

Lastly, in this connection we note that the normal individual belonging to a stock which is affected by some deplorable recessive character may either be a pure dominant, D D, and free to beget offspring for the botanist, the stock-raiser, or for mankind, or may be an impure dominant, who should not become a parent, or who, at the very least, should only mate with a pure dominant.

The student will see the incalculable significance of the Mendelian discovery and of genetic research for practice of many kinds. When he later comes to study eugenics in this work, and during the ordinary lifelong discharge of his duty as a thinking and responsible citizen, he will need to keep the principles of genetics ever before him, otherwise the best intentions might lead himself, or the State representing him, to forbid what would really be worthy parenthood, or to encourage that which might prove to be highly disastrous.

C. W. SALEEBY

The World as a Market. Value of the Board of Trade and Chambers of Commerce. Commercial Travellers Abroad. Export Journals.

FINDING NEW MARKETS

In these days of fierce competition and rapid output, the manufacturer has constantly to be on the look-out for new markets, in order to place the goods that he is producing in ever-increasing quantities. With the costly machinery that is necessary in every manufacturing business today, it is only by continuous production that the establishment or overhead charges can be reduced to a satisfactory minimum, and it is this continuous and rapid production that gives rise to the need for new markets.

The World as a Market. It is, of course, in the world at large that the merchant seeks to develop his business. The home markets are at his door. He knows them well, and the routine of supplying them presents no difficulty. There are certain recognised routes, with more or less rapid delivery; packing is a much easier problem than it is in the case of the export trade, and naturally the merchant seeks, as far as possible, to exhaust the home trade before looking further afield. But it is not long before he gets a wider vision, and then, to use an old saying out of its context, his "eyes are in the ends of the earth."

Business and Exploration. To a very large extent it is the surplus stocks resulting from the invention of labour-saving devices and machinery, with the consequent increased output, that have led to the opening up of the world. The pioneers of exploration have in many cases been the traders; and while in days so recent as those of the middle of last century the man who needed new markets abroad had practically to go himself, or to send out to find them, now a great deal of valuable help, which takes the trader far beyond the preliminary stages, is rendered by the Commercial Intelligence Department of the Board of Trade, whose offices are situated at 73, Basinghall-street, London, E.C., in the very heart of the commercial world.

Help from the Board of Trade. The sole object of the department is to give every possible information and assistance to merchants and manufacturers. In the words of the handbook of the department, it "is intended to be a centre at which information on all subjects of commercial interest shall be collected and focussed in a form convenient for reference, and at which, so far as the interests of British trade permit, replies shall be given to inquiries by traders on commercial matters." The offices contain an inquiry-room, where personal inquiries may be made on the various subjects dealt with by the department; a sample-room, with specimens of manufactured articles which compete with British goods, and of raw products forwarded from foreign countries or British possessions by his Majesty's consuls, trade commissioners, and other authorities; and a reading-room, where the latest official publications, British, Colonial, and foreign, and the latest issues of trade directories may be consulted and extracts made. If required, the assistance of the staff will be given. The department has specially appointed trade correspondents in the British dominions; and as to foreign countries, his Majesty's diplomatic representatives abroad, with the commercial attachés and the consular officers, have been instructed by the Foreign Office to forward without delay any information which may seem likely to be of interest to British trade.

Useful Statistics Available. A vast deal of statistical information is available in this Commercial Intelligence Branch of the Board of Trade with regard to the imports and exports into and from the United Kingdom, showing the quantities and values of articles imported from or exported to each of the principal foreign countries and British possessions. This, of course, is extremely useful to merchants and manufacturers who want to know where the best markets are for certain lines of goods. When statistical information as to imports and exports of the United Kingdom is required in greater detail than is given in the published official returns, such information can often be obtained on application to the Principal of the Statistical Office, H.M. Customs, London, E.C.

The statistical section of the Board of Trade Commercial Intelligence Branch has, of course, a great deal of other information tabulated and arranged for easy reference, such as particulars of the shipping, British and foreign, which enters and clears at the British ports; the number and tonnage of the British mercantile marine, and so on. Information can also be given as to the wholesale and retail prices of various articles over a series of years, and as to the numbers of persons at present employed in the different industries of the country.

Information About Foreign Tariffs. The Customs tariffs and regulations of foreign countries and of British possessions are filed at the Commercial Intelligence Branch, and kept corrected up to date. This information is extremely necessary, and of great value to the merchant seeking new markets abroad. If required, information will be given by the courteous officials, or translations of the complete tariffs of the various countries may themselves be consulted by the inquirer.

It is not, however, necessary to go to Basinghall Street to gather any required information of this kind about a country to which it is proposed to send goods. The Board of Trade publish annually two important Returns, one of which gives in a concise form detailed information respecting the rates of Customs duties in

European countries, Egypt, the United States, the Argentine, Mexico, Japan, China, and Persia, and the other similar information with regard to British colonies and possessions. The duties are given for all the principal articles of export from the United Kingdom. The first of these Returns is called "Foreign Import Duties," and the other "Colonial Import Duties." Either may be bought for a shilling or two. In the "Colonial Import Duties" full particulars are given as to the preferential tariff advantages granted by certain colonies in favour of British goods, as well as information respecting colonial copyright laws and regulations, and parcel post regulations concerning dutiable articles.

In the "Foreign Import Duties" Return information is given as to gross or net weights on which the Customs duties are levied, and the tare allowances which are made in the case of goods dutiable by net weight. These valuable returns are revised annually at the close of each year, but alterations in Customs tariffs are noted in the weekly "Board of Trade Journal," so that merchants and others who subscribe to this journal are able to keep their tariff knowledge right up to date. It must be remembered that applications for information as to foreign and colonial Customs, tariffs, regulations, etc., must be made to the Commercial Intelligence Branch of the Board of Trade, and not to the Customs authorities, who do not deal with such questions.

Lists of Foreign Buyers. Another valuable operation of the Commercial Intelligence Branch, which is of the greatest use to merchants and manufacturers seeking new markets abroad for their goods manufactured at home, is the compilation of lists of possible buyers of British goods whose names have been received from consuls and trade correspondents of the branch. These lists are not published, but are kept for use in replying to inquiries from British manufacturers and traders. They are also available for consultation at the offices in Basinghall Street by British merchants and manufacturers. These lists are, from time to time, sent for revision to the consuls and correspondents. Special lists obtained in reply to specific inquiries are also received and filed for use in like manner. Lists of the kind described are now available for over sixty foreign countries, and for about fifty British colonies.

The lists are classified under various trades, and their value to the merchant seeking new markets abroad cannot be overestimated. Lists of possible foreign buyers are available under the following, among other, headings: arms and ammunition, athletic and sporting requisites, carpets, chemicals and drugs, coal, cotton goods, cutlery, cycles and accessories, fancy goods, fish, groceries, hardware, hats, hosiery, iron and steel, linen goods, machinery, millinery, motor-cars, oils, optical instruments, photographic requisites, provisions, shipchandlery, soap, stationery, tea, tobacco, wines and spirits, woollen goods, etc.

Other Useful Lists Available. The department is also able to supply in some instances supplementary lists of general commission agents, solicitors, patent and trade mark agents, firms (other than legal) who undertake the collection of debts, trade inquiry offices from which reports may be obtained as to the financial standing and trade reputation of local firms, and newspapers likely to be of use for purposes of advertisement. The financial standing of firms is not reported on officially, but the colonial correspondents of the Commercial Intelligence Branch and his Majesty's consuls, although not bound to reply to inquiries of the kind, are allowed, at their own discretion, to make statements in general terms with regard to any firm about which inquiry may be made.

Bringing Buyers and Sellers Together. The lists of possible buyers are compiled from directories and other sources of information, but it must be distinctly understood that the department takes no responsibility whatever with regard either to their accuracy or to the financial stability of the firms included therein. The object of the Commerical Intelligence Branch is to facilitate, as far as possible, the bringing together of the foreign or colonial buyer and the English seller. The department declares that, while it cannot entertain any application from individual traders to be included in these lists, buyers who desire to take advantage of the "Board of Trade Journal" for the purpose of communicating with British manufacturers should apply, stating their requirements, to certain specified authorities. Firms in the self-governing dominions have to apply to the High Commissioner or Agent-General, as the case may be, in London, or to his Majesty's Trade Commissioner in the particular dominion, or to the Imperial Trade Correspondent or the Chamber of Commerce in their district. Firms in India apply to the Director-General of Commercial Intelligence, Calcutta, or to the Chamber of Commerce in their district. Firms in the Crown colonies and protectorates must apply to the officers appointed by the respective governors to deal with trade inquiries, or the Chamber of Commerce in their district. Firms in foreign countries must apply to the British consul or to the British Chamber of Commerce, if there is one, in their district.

When a firm has thus applied, if in the exercise of his discretion the authority receiving the application forwards it to the Board of Trade in London with an expression of willingness to answer further inquiries, a notice may be inserted in the "Board of Trade Journal," where the British merchant or manufacturer will see it.

Directories for Consultation. The department has a large library of directories and year-books, British, colonial, and foreign, available for consultation, and these apply to practically every country in the world. The English section of the library includes all the recognised directories of special trades.

Foreign Contracts Open for Tender. Information as to foreign and colonial contracts open to tender are sent to the Commercial Intelligence Branch by his Majesty's consular

officers in foreign countries, and by the trade commissioners and correspondents in the various British colonies and dependencies. These officials are instructed specially to report any such openings for trade, and, if necessary, to communicate the information by telegraph. The department also collects notices of the kind in question from official and other publications received from abroad, and such notices are published in the "Board of Trade Journal," and are often communicated directly to British manufacturers who are on a special register for the receipt of confidential information. This register and its use will be referred to in detail later. The original documents from which these notices are taken may usually be consulted at the offices in Basinghall Street, and, when practicable, specifications and tender forms are also available to British manufacturers.

In the "Board of Trade Journal" there are also published notices of openings for trade, other than contracts.

Information About Certificates of Origin. When he is seeking for new markets further afield, it is important that the merchant or manufacturer should get full and accurate knowledge in regard to such matters as certificates of origin and so on. The Commercial Intelligence Branch of the Board of Trade supplies all this. Information regarding the regulations existing in British India, the British self-governing dominions, the Crown colonies and protectorates, and also in foreign countries, with regard to certification of origin for imported goods, the certificates of invoices, etc., is embodied in a published memorandum, which can be bought for a few pence or consulted at the branch. Special pamphlets containing the regulations relative to the certificates required in Canada, South Africa, Australia, and New Zealand may be obtained on application to the department. The Commercial Intelligence Branch also receives and files the latest available information as to any changes in the regulations.

Regulations Concerning Commercial Travellers. Another very valuable pamphlet for those seeking new markets abroad is one containing the latest information concerning the regulations in force in various countries with regard to commercial travellers. The memorandum gives full information as to formalities to be complied with and taxes to be paid, and shows the Customs regulations in force as regards the importation of commercial travellers' samples, and the facilities granted to commercial travellers on the railways. Information is also given as to the regulations in force in the United Kingdom, and the reciprocal arrangements made between the United Kingdom and certain foreign countries and British possessions as to special Customs House facilities in respect to the introduction of commercial travellers' samples. Some points in regard to travellers abroad are given later in this chapter.

Confidential Information for Traders. The Commercial Branch of the Board of Trade also supplies special private information that is not published or issued in the ordinary sense. Firms in the United Kingdom desirous of receiving confidential information as to opportunities for the extension abroad of those branches of trade in which they are specially interested, and as to other connected matters, may, upon application, have their names placed in a special register at the Commercial Intelligence Branch. The confidential information communicated to firms so registered relates mainly to openings for British trade abroad, and is received from his Majesty's consular officers in foreign countries, from trade commissioners, and the Imperial trade correspondents in the British dominions, and from the Board of Trade correspondents in the Crown colonies, supplemented by information from other sources available to the Commercial Intelligence Branch. Firms inscribed on the register may indicate the particular lines of trade to which the information to be sent to them should relate, and a classified list of subjects is sent to all applicants for registration with this object. In this list there are twenty-two main divisions, as follows: 1. Public works, contracts, schemes, including eleven sub-divisions such as railway construction, tramway construction, waterworks, drainage and sewage works, electric power and lighting, telegraphs and telephones, and so on. 2. Iron and steel, including nine sub-divisions—bridge-work, railway and tramway material, iron and steel pipes and tubes, galvanised and corrugated iron, etc. 3. Hardware, etc., with the sub-divisions cutlery, hardware and ironmongery. 4. Hand implements and tools. 5. Machinery and appliances, with fifteen sub-divisions, such as agricultural and horticultural implements, electrical machinery, mining, winding, boring, and hauling plant, steam-engines and fittings, saw-milling and wood-working machinery, etc. 6. Locomotives, railway and tramway rolling stock, with the sub-divisions locomotives and rolling stock. 7. Traction-engines, road-rollers, steam tractors. 8. Fire-extinguishing apparatus and appliances. 9. Shipbuilding. In these there are several sub-divisions—war vessels, passenger and cargo vessels, tug-boats, river steamers, dredging plant, floating docks and pontoons, motor-boats, launches, and similar craft. 10. Vehicles, including motor-cars, lorries, and waggons, motor-cycles and cycles, carriages, carts, and trucks. 11. Metals and minerals (excluding iron and steel), coal, coke, patent fuel, brass, copper, aluminium, lead, tin, etc. 12. Textiles, including cotton yarns and fabrics, woollen and worsted yarns and fabrics, silk yarns and fabrics, linen, lace, and hosiery, hemp and jute goods of all kinds. 13. Raw cotton and wool, cotton waste, hair and other fibres. 14. Carpets, linoleum, oilcloth. 15. Clothing and accessories. 16. Hides, skins, furs, and animal by-products. 17. Leather and leather goods, including boots and shoes and saddlery. 18. Chemicals, paints, oils, etc., including soap, candles, starch, and so on. 19. Building and paving materials—asphalte, cement, marble, granite, stone, slate, bricks, tiles, lime, sand, timber, etc. 20. Building

accessories, such as furniture, heating, cooking, and ventilating apparatus, gas-fittings, and so on. 21. Provisions and drink, with six subdivisions—fish, fruit and vegetables, groceries and provisions, cocoa, chocolate and confectionery, cereals, flour, etc., wines, beers, spirits, and mineral waters. 22. Various, with fifteen main sub-divisions, many of which are still further sub-divided. The lines here enumerated are very miscellaneous, and include glass and glassware, earthenware, china, paper, stationery of all kinds, rubber and rubber goods, firearms and explosives, fancy goods of all kinds, clocks, watches and jewellery, scientific and surgical instruments, musical instruments, photographic apparatus, kinematographs, phonographs, etc., brush and basket ware, tobacco, cigars, cigarettes, and snuff, matches; the shipping and carrying trade, and insurance.

It will thus be seen that the confidential information collected and distributed by the department covers practically the whole range of business activities.

The Value of the Confidential Information. As can be imagined, this information, available practically for the mere asking, is of the greatest value to the merchant or manufacturer seeking new markets, and can be obtained in no other way. Only a Government department with consuls and officials to call upon in every part of the world could afford to collect such a mass of information and make it available for business men at large. As a writer recently said: "If we are adequately to cope with foreign competition, an extension of our knowledge of oversea markets is essential. This knowledge must include a clear idea of the extent and nature of the trade to be done, the tariff duties to be paid, transportation rates, both by sea and land, etc. Whether it come direct through the manufacturer's own organisation, or through the medium of the middleman, is of little concern so long as the result is the same. There is a distinct preference for British goods on the part of buyers all over the world, but faulty methods of distribution have precluded our efficiently satisfying an existing demand. Where we have failed, foreign firms have stepped in, and have secured business which should have been ours, and this almost entirely because of their own knowledge of conditions, and of the facility which has been given to them for acquiring such knowledge from other sources."

Help from Chambers of Commerce. But valuable as is the Commercial Intelligence Branch of the Board of Trade, it is not the only source from which the merchant or manufacturer seeking new markets can get help. He will be able to learn much that is indispensable from the various Chambers of Commerce at home and abroad, and should certainly become a member of one of the Chambers. In addition to the ordinary Chambers of Commerce in London and other large cities, there are in London nine Anglo-foreign Chambers of Commerce—the Anglo-Belgian, the Anglo-Portuguese, the Austro-Hungarian, the French, the Italian, the Netherlands, the Norwegian, the Spanish, and the Swedish, and from any of these can be obtained much practical information.

Then there are British Chambers of Commerce in many of the large business centres abroad, such as Paris, Brussels, Genoa, Milan, Constantinople, etc. Membership of these is open to British subjects, and some others interested directly or indirectly in the trade and international commerce between the particular countries in question and the United Kingdom and the United States. The Chambers, among other things, afford facilities to British, American, and colonial firms desiring agents and representatives in the foreign country, and, vice versa, to foreign firms seeking to extend their connections in England and America. They also collect useful statistics, obtain legal opinion relating to foreign legislation, promote measures calculated to benefit, protect, and forward the mercantile and trading interests of their members, and intervene with the foreign Customs authorities on behalf of their members when they have a *prima facie* reasonable case. As membership can be obtained for practically a nominal sum, every manufacturer or merchant thinking of attacking new markets in any foreign country would certainly find it pay him to become a member of the Chamber of Commerce in that country, if one exists. The Chambers furnish information as to the commercial standing of firms in the foreign country, and some of them even collect debts for members.

The Value of Trade Journals. The trade journals of this and other countries should be studied carefully and systematically, and from these also will be gleaned a great deal of useful information which may suggest new markets and give hints as to how they may be reached. The trade and export journals keep the manufacturer and merchant posted as to what his rivals are doing.

Commercial Travellers Abroad. Reference has already been made to the regulations and taxes for commercial travellers operating in foreign countries, and it is important that a merchant or manufacturer sending out representatives to get business abroad should know just what they are. Any traveller soliciting business in these countries without the necessary licence is subject to a fine. The regulations vary in the different countries.

France. In France, for instance, travellers may enter and go about quite freely, and their samples are admitted without the payment of duty. A deposit, however, has to be made, or a guarantee of payment given, for the amount that these goods would pay in the ordinary way. Each sample is marked, and the traveller undertakes to remove the goods from the country or place them in bond within twelve months. The deposit is refunded when the goods are re-exported.

Germany. In Germany there is very little in the way of regulation. The traveller can go about quite freely, but he must take out with the police or municipal authorities a licence,

costing one mark. In addition, there is a small tax to pay to the particular country of the empire in which the traveller is working. He may carry samples and patterns, but not the actual goods he is selling, and even on samples, if the goods they represent are dutiable, the duty must be paid.

Greece. This country places no restrictions on commercial travellers beyond the stipulation that they shall carry only samples that are of no commercial value. No duty has to be paid on these, provided they are re-exported within twelve months.

Belgium. Here the traveller may come and go as he pleases, but in order to get his samples through free of duty he must get the British Customs authorities to mark or seal his samples when he leaves England, and to give him a list of these, officially attested. Such document is accepted by the Belgian authorities as testifying that the samples are genuine and in order.

Italy. In Italy commercial travellers are subject to no restrictions whatever, and genuine samples pay no duty.

Spain. Commercial travellers here must carry certificates of identity issued by a Chamber of Commerce and bearing the seal of the Board of Trade. Then they may exercise their calling without hindrance. No fee or licence is necessary. Samples do not pay duty, but certain formalities have to be complied with to ensure that they will be re-exported.

Austria and Hungary. The traveller seeking orders must have a certificate of identity issued by a Chamber of Commerce or the mayor of his town, and there are various harassing regulations which greatly handicap business and make these countries a very difficult market. Except for a few lines of goods, the traveller is not allowed to seek orders from private individuals, and he must deal directly with the firms who actually use the goods offered. If, however, he has received a spontaneous invitation to call, he may do so, but even then must confine himself to some particular line of goods that has been asked for, and not try to sell promiscuously a number of different lines. Samples are admitted free of duty, but a deposit or guarantee of the duty that would be payable in the ordinary course must be given, which is refunded when the goods are re-exported. Patterns and samples are carried by the Austro-Hungarian railways at a reduced rate, provided the traveller has a certificate from a Chamber of Commerce saying his goods are genuine samples.

Holland. In Holland there are various restrictions. The traveller must first of all give, in writing, to the municipal authorities of the place first visited by him after May 1—the opening of the Government's financial year—his name, address, and profession. Then he must secure from the burgomaster a certificate, which he must sign. This is not charged for, but before the traveller can obtain it he must produce a declaration from the collector of taxes that he has paid the annual tax, equal to 25s., that is levied on all commercial travellers. Small samples of no commercial value do not have to pay duty, but in others the duty is levied, and refunded if the goods are re-exported within twelve months, and provided the burgomaster's certificate is produced.

Portugal. The traveller who is making a stay of more than a week in Portugal has to take out at his consulate a licence, which costs him 2s. 6d. He must then carry this to the police authorities and get them to endorse it, paying a fee equal to 7s. 4d. Samples are admitted free of duty, unless the duty that would be payable exceeds three hundred reis—equal to just over a shilling. In such a case the duty must be paid, but is refunded if the goods are re-exported within six months.

Russia. The traveller going to Russia must bring with him a passport. Then on arriving he must take out at the Custom House a personal licence costing him fifty roubles—just over five guineas; and a trading licence for his firm, which costs a hundred and fifty roubles—equal to about £15 16s. 6d. He must further pay certain provincial and town dues, each equal to five guineas, and various local dues also have to be paid. But before he can obtain any of the necessary licences in Russia, the traveller must show a certificate of licence to trade from a British Chamber of Commerce; and when he takes out a licence on behalf of his firm he must produce a power of attorney or letter of authorisation from the firm. Duty has to be paid on all samples, but this is refunded when the samples are re-exported; and there is no restriction as to how long the samples may remain in the country. In Finland there is no tax whatever on commercial travellers.

Switzerland. Here the traveller must have a licence. which is issued free of charge to travellers selling goods to Swiss firms for resale, or for use in their businesses. In other cases a charge of a hundred francs—about four pounds—is made for the licence. It lasts for six months, but a twelve months' licence may be taken out, and the charge is then 150 francs (six pounds). In the first canton which he visits, the traveller must produce before the authorities a certificate of identity from a British Chamber of Commerce or mayor, declaring that the firm he represents is authorised to do business in the United Kingdom.

Denmark. This is a difficult country for the commercial traveller. On arriving he must obtain a licence available for one year, licences for shorter periods not being granted. For this he pays the Customs authorities about nine pounds. If he represents more than one firm, he must pay half the tax for each additional firm. In order to obtain the licence the traveller must, on his arrival in the country, produce a certificate of authorisation signed by his firm, attested by a public notary, and viséd by a Danish consul. If by any chance he cannot produce this certificate of authorisation, he can obtain, on payment of 64 kroner—that is, about £3 11s.—a temporary licence allowing him to do his work; and if within four weeks he takes out a full

licence, the 64 kroner for the temporary one is returned. But his dealings with the authorities are not finished; in every town he visits he must take his licence to both the police and the Customs authorities for them to endorse. The duty which has to be paid on all samples is refunded if these goods are re-exported within three months, but proof of identity that the samples are the ones on which the duty was paid is demanded.

Norway. Here the traveller is obliged, directly he arrives, to obtain from the nearest police-office a trading licence, which costs a hundred kroner—about £5 11s. This lasts for only one month, and for every subsequent month that he remains he must pay a similar charge. Duty need not be paid on samples that are without commercial value, and the duty on other samples is refunded when the goods are taken out of the country.

Sweden. In Sweden the traveller must take out a licence, costing a hundred kroner (£5 11s.), and the receipt for this sum, which he receives at the time of payment, must be shown to the police authorities in every town he visits before he begins doing business there. The licence lasts for thirty days only, and for every additional fifteen days fifty kroner are charged. The arrangements as to duty on samples are very much the same as in the case of Norway.

The Balkan States and Turkey. In Bulgaria, the traveller has to take out a licence costing three pounds for every six months, with an extra charge for every additional firm represented by him, and to obtain the licence he must show a certificate from a British Chamber of Commerce or a British consul. In Roumania the traveller must bring with him a passport and a certificate from a Chamber of Commerce. Then, on arriving, he must get from the police authorities a permit; and if he declares that he intends to take orders from private individuals as well as from business firms, he must take out a quarterly licence, the fee varying according to the goods he is selling. In Servia the traveller must carry a certificate from a Chamber of Commerce, a mayor, or a Servian consul. In Turkey the traveller needs no licence, but he must have a passport viséd by a Turkish consul.

For other countries full particulars may be obtained from the Commercial Intelligence Branch of the Board of Trade, as indicated.

Importance of Carrying a Passport. No business man intending to travel on the Continent should fail to obtain a passport before he sets out, for such a document is practically indispensable. It is quite easy for a British subject to secure a passport, although there seems to be a general opinion, even among business people, that there are great difficulties in the way, or that much trouble will be involved. As a matter of fact, what the prospective traveller has to do is to write to the Passport Department of the Foreign Office, asking for the regulations that govern the issue of passports. In reply, he will receive a copy, on the back of which is a form of application and certificate of identity that must be filled up, the latter being signed by the applicant's doctor, banker, or solicitor, or by some other official person. The document is sent to the Passport Office with a fee of two shillings (postal order), and if the applicant lives in London he has to call for the passport and affix his signature to it. If he lives in the country, the passport is sent to the person who signed the certificate, and this person has to witness the applicant's signature to the document. The passport will remain in force for five years, and at the end of that time it can be renewed if it be sent to the Passport Office with a postal order for two shillings. For persons about to travel in Russia, Turkey, or Roumania the passport must be viséd by a consul of the country in question.

Travellers Representing Several Firms. Reference has already been made to travellers representing more than one firm. Where business houses are making an effort to extend their trade in new markets abroad, and wish to be represented by a traveller, it is often a non-paying proposition to have a man representing themselves alone. In such cases it is usual for a firm contemplating an extension of this kind to communicate with other firms handling different goods, though in the same class, to share the expenses and the services of the traveller. The plan has been found to work quite satisfactorily, but of course there must be a distinct understanding as to the terms and methods of working. In other cases a traveller representing one house will get permission to find another firm which he can represent, but in any such case the first firm, of course, reserves the right of approval or disapproval of the second firm suggested.

Hours of Business Abroad. British business men going abroad to seek new markets must bear in mind that office hours differ considerably from the hours observed in the United Kingdom. Work starts much earlier, often at six in the morning, and continues later at the close of the day. But in many countries, especially those where the climate is warm, as in Spain, Italy, and Portugal, the midday interval lasts for two, three, or even more hours. In some parts of Germany there is a midday interval of a couple of hours. In the countries of Southern Europe the number of saint-days and fête-days, when business is suspended far exceed the few Bank Holidays known to England.

A word must be said about dress for the guidance of business men thinking of travelling abroad. There is far less formality than here, and an ordinary lounge suit with a soft felt hat is quite in order, and the recognised costume for all business calls except those of the most formal character.

Need of Foreign Languages. Of course, it goes without saying that any merchant or manufacturer who is anxious to extend his business to new fields in foreign countries must see that all his communications with the traders of the country in question, whether they be by travellers or by letters, must be in the language

of the foreign country. Weights, measurements, and quotations, too, should be in the metric system. It is because rival commercial nations, such as the Germans and the Americans, adapted themselves in this way, and the British merchants for so long declined to take the necessary trouble to do so, that these rivals went ahead so rapidly. Dealing with this matter as it affected British interests in Roumania, our consul wrote some time ago: "It is pleasing. to observe that a greater number of British firms have endeavoured during the past year to establish commercial relations with Roumania, but it would be still more pleasing if British manufacturers would realise that, however artistically and attractively their pamphlets or price-lists may be got up, and however reasonable their prices, they are absolutely valueless from a commercial point of view so long as all information is written in English, with English prices and measurements attached. Commercial men here do not know English (with individual exceptions), and will not be bothered labouring through a catalogue with the help of a dictionary and a comparative money-table. The bulk of the dealers here talk or understand German, and Germany and Austria-Hungary pour into the country German-speaking travellers, and price-lists and catalogues written in German, with the measurements and prices based on the decimal system. It is much to be regretted that British firms cannot see their way to realise that, widespread as the English language is, it is not yet ubiquitous, and that it is simply a waste of printing and postage to send catalogues in English to countries where that language is not spoken. They need merely ask themselves how they would treat a catalogue written in Turkish, and may be assured that a similar fate undoubtedly awaits their own pamphlets."

Advertising to New Markets. Of course, advertising plays as large a part in a successful export trade as it does in a big home trade. The mere selling of a line of goods to an agent will not do much to increase business unless the foreign public is moved to ask for the goods. The various methods of advertising in the foreign country in which a new market is sought, should be studied. Posters, showcards, and the columns of newspapers all play their part, but it must be remembered that, so far as the Continent of Europe is concerned, displayed advertisements, such as posters, etc., are on the whole more artistic than in this country. Announcements must, of course, be in the language of the people concerned.

The Kinematograph on the Continent. On the Continent the kinematograph is used much more than it is here for the purpose of advertising ordinary commodities. A regular system has been devised of introducing comic and mysterious turns of general interest, which in the end lead up to an announcement about some article of household or everyday use. For instance, there will be thrown on the screen scenes in a humorous competition among women as to which can wash out linen so as to produce the best result in the shortest possible time. All but one will work like Trojans, and apparently fail to get satisfactory results, but there will be one washerwoman who, without making much effort, will hold up a spotless garment. Then as the explanation of her success she exhibits a packet of So-and-so's soap. A comic story will be shown centring round a mysterious parcel that is found in the street, and this in the end is opened, and proves to be Such-and-such a firm's cocoa. Or a package will dance on to the screen, and, after going through various antics, will open. apparently without human aid, and from it will march an endless stream of bottles of So-and-so's soup essence. The British merchant or manufacturer seeking to make a profitable market for his goods on the Continent, particularly in Germany, cannot afford to ignore this very popular form of advertising.

Transport. Methods and routes of transport to the markets sought must be carefully studied. The fact that the state owns the railways and waterways in so many foreign countries simplifies matters a great deal, and through routes by rail, river, and sea are a great boon. Particulars of routes and rates may be obtained by application to the offices of the State Railways of various countries, some of which have branches in London. The whole question of routes abroad is a big one, which needs exhaustive study by any merchant or manufacturer who seeks to extend his business.

The C.O.D. System. There are many advantages which the trader abroad enjoys which are not available in the United Kingdom. The C.O.D. (cash on delivery) system, for instance, is brought to a very high state of efficiency in Continental countries. The Post Office, by this system, undertakes to collect the cost of a parcel at the time of delivery; and as the different countries participate in the arrangement, it is possible to send goods from one country to another, getting the Post Office to collect the debt at the time of delivery, and to forward to the seller. In this way neither the buyer nor the seller has to worry whether the other party to the transaction is honest or not. The goods are sent C.O.D., and so the buyer cannot lose his money, as he does not send it on first; nor can the seller be swindled, for the goods are not delivered without the cash. Goods may also be sent by rail or by water, C.O.D.

Government Monopolies Abroad. It must be remembered that in several foreign countries the Government has a monopoly of certain lines of business. In France, Austria, Italy, and Roumania, for instance, the whole of the manufacture and sale of tobacco, cigars, and cigarettes is exclusively in the hands of the Government. The French and Roumanian Governments also reserve to themselves a monopoly of the sale of matches; Roumania adds playing-cards to her other Government monopolies, and Italy salt, while in Switzerland the Government monopolies are salt, gunpowder, and the preparation of alcohol.

CHARLES RAY

What Colour Is. Why the Sky Is Blue. The Dust and the Sunset. Complementary Colours. The Mind and Colour. Vision. Colour Blindness.

THE MYSTERY OF COLOUR

We know what colour is essentially—that it is precisely comparable to pitch in sound, and that one pure colour differs from another, if the complications introduced by our seeing apparatus be ignored, neither more nor less than red differs from the infra-red heat rays, or F from G.

How Colour is Made. Colour is a matter of wave length and of frequency of vibration. The onward speed of all forms of light is the same. Indeed, we have seen that this speed is one and the same for ethereal vibrations in general, and not merely for the octave we call light; but the factor of time enters in an entirely different way into our study of light. For though red and violet light both pass onwards at the same speed, the vibrations constituting the first occur at the rate of four hundred billions (400 millions of millions) per second, while those constituting the latter are about twice as frequent. There is a due proportion between wave length and frequency, so that as the wave length becomes shorter the frequency of the vibrations increases. It is when we think in terms of frequency per second that we recognise, most completely, the precise parallelism between colour and pitch. We turn now to a further study of colour as dependent upon the relation between ethereal waves and material matter; and also as dependent upon the peculiarities of our retinæ. The analogy with sound will help us no longer, but we shall be helped, in some measure, by our previous study of *Radiant Heat*.

Why Red is Red. It was a saying of St. Augustine's that light is the queen of colours. We may read a modern meaning into this if we consider the reason why a piece of red glass appears red. So long as no light is allowed to fall upon or pass through the glass it has no colour, but is as black as everything else about it. Its redness, then, depends upon the manner in which it acts on the light which it receives. White light is the queen of colours because it contains all the colours, and a piece of red glass is red because it transmits the red elements in white light, but is opaque to all the others. Why it should be transparent to red, but opaque to everything else, is a further question which we can make no attempt whatever to answer. If the reader will consider it for a moment, he will see how difficult it is, and how entirely it depends upon an adequate knowledge of the nature of matter itself.

Meanwhile, we must content ourselves with the empirical unexplained fact that certain kinds of matter have certain relations to ethereal waves of certain lengths. The explanation of the redness of a red object is thus only partial, but it is unquestionably true as far as it goes; and it applies alike to bodies which are red by transmitted light and those which are red by reflected light. A piece of red paper is red because it absorbs all the constituents of the white light which falls upon it, except the red which it reflects.

These assertions can easily be proved by experiment upon the spectrum. We find that a piece of red glass reduces the spectrum of white light to its red elements, cutting off the others, while a piece of red paper appears red in the red part of the spectrum, but black everywhere else—because it is compelled to absorb all light except red.

What Makes the Sky Blue? It is this principle of selection which explains many of the most glorious colours of Nature. If we ignore, as we may, the stars, nebulæ and comets, and the moon and planets that gain their light from the sun, then all the colours of the sky and sea and land are to be referred to the white light of the sun. Why, then, should the sky be blue? This subject was very carefully studied by Professor Tyndall, who showed, now about fifty years ago, that the explanation is to be found in the presence of excessively fine particles that float in the atmosphere and, because they are so fine, scatter light of very short wave lengths, while allowing light of longer wave lengths to pass through. Doubtless there is a certain amount of scattering of all the rays, but the short blue waves are much more scattered than the others, and thus endow the sky with its blue colour. It is a somewhat prosaic explanation of the spendid colour which we associate with the firmament, that it is due merely to minute particles of "dust" in our atmosphere—the total thickness of which, of course, as compared with celestial distances, is infinitesimal.

How the Dust Paints the Sunset. Reference has already been made to the peculiar shape presented by the sun when it is very near the horizon. It is now our business to explain the magnificent colouring which we see at sunrise and at sunset. The light leaving the sun is white at all times. What, then, is the reason of the apparent redness of the sun when it is near the horizon, and of the colouring that is produced around it? The answer is that when the sun is near the horizon, and the rays are piercing the atmosphere very obliquely in order to reach our eyes, its light is affected much more by the particles in our atmosphere than when the sun is overhead—since it encounters more on its way. As must be, the blue rays are especially scattered, and it is by the red rays especially that we see the sun

at such times. Every Londoner is familiar with the fact that the presence of an exceptional amount of dust in the atmosphere on a foggy day similarly affects the appearance of the sun. Indeed, it may be said that the sun is never white in London, but is yellow even at noonday. It was once remarked by M. Rodin, the great French sculptor, that Londoners are fortunate in the magnificent effects of colour which their sky often yields them. This is some compensation, but a very inadequate one, for the filthy and health-destroying fashion in which we burn our coal. Lastly, it may be noted that whenever a large amount of volcanic dust is thrown into the atmosphere exceptionally brilliant and magnificent sunsets are observed. This was the case after the eruption of Krakatoa, the eruption at Martinique, and the last eruption of Vesuvius.

Complementary Colours. We now turn to a subject which is on the borderland between physics and psychology, and which can never be properly understood unless we are careful constantly to distinguish between the phenomena which have a physical or objective explanation and those which have a psychological or subjective explanation. Let us begin, first of all, with the physical.

It is the physical fact that the light which we call white can be decomposed into a spectrum. It is also, as might be expected, the fact that the various colours thus decomposed can be re-composed or combined so as to form white light again. This can be done by throwing the spectrum on to a series of mirrors, so placed that they all throw the light falling upon them on the same spot on a dark screen. The spot reflecting to the eye simultaneously this mixture of rays will appear white. Various other means will produce the same result, provided that, as in this case, not only are all the necessary colours present, but they are present in the proportions in which they exist in white light. Now, if we manipulate our apparatus so as to prevent the green constituent of the light from falling upon the screen, we shall find that the illuminated part of the screen is no longer white, but red; or, if the yellow constituent of the light be interfered with, the spot will appear blue. The relation between such colours as blue and yellow which, taken together, form white light—so far as our eyes are concerned—is expressed by the word *complementary*. This means that if white light be taken as full light, blue fills up yellow to that fulness (Latin *pleo*, I fill).

The Absorption of Light. We must distinguish very carefully, however, between the behaviour of lights of complementary colours, such as blue and yellow, and pigments of corresponding colours. If blue and yellow lights are mixed together, the result is white light, but, as everyone knows, if blue and yellow paint are mixed together, the result is not white paint, but green paint. For the moment this may appear paradoxical, but it will seem so no longer if we think more carefully of the difference between the two cases. In the case of the paints, their colour depends solely, as we have already seen, upon the colour of the light which they are not able to absorb. The light which cannot be absorbed by blue paint, but is reflected by it, is green, blue, and violet. Similarly, yellow paint reflects merely red, yellow, and green. This is as much as to say that when the two paints are mixed, the only colour which they cannot absorb between them is green, and hence that is the colour of the mixture.

A simple device will show the difference between mixing blue and yellow paints and blue and yellow lights. The latter can easily be done by any of many methods, and the result is the production of a white or grey light.

Colour Impressions on the Eye. Newton began the study of this subject by a very simple and effective method, "the use of rotating discs which quickly superpose on the same area of retina different impressions of colour." Newton gave precise directions for the size of the seven sectors bearing the seven colours, from red to violet, which were to be painted on a disc of cardboard, so that, when the disc was rapidly rotated, it appeared to be of a uniform grey, approaching more and more to whiteness in proportion to the strength of the light by which it was illuminated. Clerk-Maxwell had the excellent idea of applying Newton's colour disc so as to make a colour-top. This is simply a flat top of a size suitable for holding a number of coloured discs, made with a hole at the centre so that they can slip over the handle of the top. Each disc has a slit in it, so that various pairs of discs may be fitted into one another, simultaneously exposing various pairs of colours in any proportions that may be desired. Then the desired result is obtained as soon as the top is rapidly spun. As the top rotates more slowly, the retina becomes unable to retain the successive impressions long enough for their combination, and thus successive flashes of colour are seen.

Deceiving the Eye. There are various ways in which the retina may be deceived so that the sensations of complementary colours are subjectively produced. Thus, after looking at a red spot very fixedly for a few seconds, one sees a green spot of similar size when one turns the eye to a white surface. The explanation of this extremely interesting though familiar fact is that the retina has refused to respond to the red constituent of the white light which is sent to it from a white surface, and so interprets the white light as green. We may possibly discern some further explanation of this when we turn to colour vision. Complementary colour sensations may also be produced subjectively by what are called *Gorham's discs*, and by various other methods. In all such cases the explanation is beyond the reach of pure physics, and must be sought in the facts of colour vision.

In another respect, also, the retina may be deceived. It interprets as simply yellow light two entirely distinct forms of external stimulus. The yellow light which, as we have seen, is given out by sodium, is a pure mono-chromatic yellow, all consisting of vibrations of one and the same length. But various other colours may be so

artfully mixed that when their combination is submitted to the eye it interprets them also as yellow. In other words, the eye has no power whatever of distinguishing between a *pure colour* and a *mixed colour*.

The Brain and Colour Sensations. The explanation of these subjective colour sensations, as also the discussion of the circumstances in which they are aroused, is of the utmost interest in relation to painting and the kindred arts. There is some evidence to show that these complementary sensations are not due to anything that happens in the retina itself, but to the behaviour of the vision centre at the back of the brain. Thus, for instance, if one eye be closed and a brilliantly-coloured object be looked at with the open eye, the complementary colour sensation may be seen in the closed eye, which suggests that, in some mysterious way, the first colour appears in one part of the vision centre in the brain, and its complementary appears in the remainder. Then, again, if a colour and its complementary are seen at one and the same time, each appears richer and finer than it otherwise would—a fact which is apparently to be explained by the theory that each colour produces the other—or, rather, a sensation of the other—in that part of the vision centre which it is not itself affecting. This it is which explains the agreeable effect of contrast, provided that it be a harmonious and not a discordant contrast. What we call a harmony of colours probably depends on the process which we have just described—each component of the "chord" of colours producing its complement in the part of the vision centre which it is not itself stimulating.

Can Colour be Standardised? There are certain elements or constants or physiological characters which are associated with every colour, and we must try to analyse these and to use, in this analysis, a series of definite terms. In point of fact, common language is never looser than when discussing colour. The language of art criticism is equally defective in this respect, words like *tone* and *shade* being used with extraordinary elasticity. It may also be noted—though we have no present remedy to offer for it—that the notation or terminology of colours in general is extremely defective. Such a term as *red*, of course, includes colours of very different wave lengths, and our attempts to define a particular kind of red are as often misleading as not. Very many students have attempted to devise some kind of notation for practical use, but none of these have hitherto been successful. Thus, when a lady wants to match a particular colour, she cannot write to the shop and say that she wants a red of 358 billions (358,000,000 millions) per second, but has to go and take a piece of the stuff with her. If we remember the analogy between colour and pitch, we shall see that there is no inherent reason why colours should not be standardised just as musical instruments are standardised to English or French pitch.

The Elements of Colour. The first character of any colour is its *hue* or *tone*. This depends absolutely and without qualification upon the wave length and frequency, and needs no further discussion.

In the second place, there is the character sometimes described as *purity* and sometimes as *saturation*. The word *tint* is sometimes employed to describe this character, but most unfortunately so. The saturation or purity of a colour depends upon the amount of white which is contained in the colour. A perfectly pure or saturated colour, such as any of the pure colours of the spectrum, contains no white whatever; whereas the more the admixture of white with the colour, the less pure it is. Plainly there may be an infinite number of degrees of saturation from, for instance, an absolutely pure red, on the one hand, to a colour, on the other hand, which one would describe as a white having the faintest possible tinge of red.

The third character of any given colour is indicated by such words as *brightness*, *luminosity*, and *shade*. The best word for its description, however, is *intensity*. The intensity of a colour, in any given case, may be determined by two factors. In the case of a given eye at a given time, it depends upon only one factor—namely, the extent or amplitude of the ethereal vibrations. It may range, of course, from the most brilliant and luminous to the darkest and most sombre shades.

A Red Rag to a Bull. Our use of the word *amplitude* will at once have shown the reader that intensity or brightness in the case of colour is absolutely parallel in every respect to loudness in the case of sound. But it must also be remembered—and this is true of sound as well—that there is a subjective or physiological factor which determines brightness or intensity, for one and the same colour may appear intolerably bright to one eye, while it is almost sombre to another. As an instance, we may take the colour red, often known as the *dynamogenous* colour—that is, the colour which *produces force*. We must believe that a red which has no marked effect upon ourselves has a far more intense influence upon the retina of a bull, which it may arouse to behaviour justifying the name of dynamogenous. In certain morbid states of the brain, and in certain criminals and in lunatics, a red colour may act similarly.

Perhaps the oldest and simplest theory of colour vision was that the visual cells of the retina—the rods and cones—are thrown into vibration in unison with the ethereal vibrations that excite them. This theory has to be dismissed if only because such rapidity of movement of ponderable matter, as distinguished from ether, is quite inconceivable. The light energy cannot merely be transferred to the visual cells; it must be transformed. We have already noted certain consequences of this transformation—electrical consequences, changes in the pigment cells, and so on.

The Theory of Colour Vision. The most widely accepted theory of colour vision, or *colour perception*, as it is somewhat undesirably called, goes by the names of Young and Helmholtz. The theory appropriately comes from these two great men, since they were both

originally doctors, who, having received a physiological training, then turned their attention to physics. It was propounded by Young in 1807, being thus scarcely less than a century old, and was revised and elaborated by Helmholtz in 1852. This theory begins by taking into account the known fact that we are not capable of receiving simple colour sensations corresponding to every colour in the spectrum, but that if three primary colours are allowed us, their combinations will yield us impressions equivalent to all colours. The assumption, then, is that our vision is trichromic—that is to say, that it is based upon three primary colour sensations. The Young-Helmholtz theory assumes, then, that the retina must contain three kinds of photo-chemical substances—that is, substances which can be chemically influenced by light. These three substances are respectively sensitive to the three "primary" colours—*red, green, and blue* or *violet*. (Thus "primary" here has only a physiological meaning—not a physical.)

How Colour Strikes the Mind. These three substances are supposed to be connected with three corresponding sets of nerve fibres, and these fibres convey to the brain impulses in various proportions according to the wave length of the light with which the retina is stimulated. The following is the statement of Helmholtz as to what actually happens under stimulation by various colours, according to the trichromic theory of vision:

"1. Red excites strongly the fibres sensitive to red, and feebly the other two—sensation, Red.

"2. Yellow excites moderately the fibres sensitive to red and green, feebly the violet—sensation, Yellow.

"3. Green excites strongly the green, feebly the other two—sensation, Green.

"4. Blue excites moderately the fibres sensitive to green and violet, and feebly the red—sensation, Blue.

"5. Violet excites strongly the fibres sensitive to violet, and feebly the other two—sensation, Violet.

"6. When the excitation is nearly equal for the three kinds of fibres, then the sensation is White."

The arguments for and against this theory might be discussed at any length. Its most celebrated modification is known as *Hering's theory*, and is about a quarter of a century old. It is really a modification of Young's theory. Both of these theories, and also all other theories that have been put forward, find their most important illustrations and tests in the extremely interesting and important fact known as *colour-blindness*.

Colour-blindness. It is not our business here to discuss colour-blindness as a disease, nor its extraordinary transmission from grandfather to grandson by means of an intervening daughter and mother who does not herself suffer. We have to discuss the disease in relation to its physics, and as regards its practical consequences. It was first named by Sir David Brewster. The most famous case on record is that of the illustrious chemist John Dalton, who had "red-blindness," and studied his own condition in the year 1794, by the aid of the spectrum. Hence the disease is often known as *Daltonism*.

We may briefly note some forms of colour-blindness. In complete colour-blindness, "the spectrum appears in shades of grey throughout, being lightest in the position of the yellow-green, and darkest at each end. A coloured picture appears like a photograph or an engraving. According to the Young-Helmholtz theory, such cases are explicable on the assumption that all the three photo-chemical substances are alike," as is indeed believed to be normally the case in the outlying portions of the retina, which can readily be proved to be incapable of perceiving colour. In other cases the whole spectrum may appear in shades of one colour, suggesting that only one photo-chemical substance is present.

Partial Colour-blindness. But the common condition met is partial colour-blindness, which may be either green-blindness, blue-blindness, or red-blindness. Of these the most important are the first and last. In green-blindness the spectrum is not shortened, but contains no green. Furthermore, it is *di-chromic* —that is, consists of only two colours, with or without a neutral area of grey. The two colours composing the spectrum are a reddish-yellow and blue. Such patients confuse bright green with dark red, and cannot see at all a dark green letter on a black ground.

In *red-blindness*, or Daltonism proper, the spectrum is shortened, since the red end is absent, and it consists merely of two colours—yellow and blue. Such patients cannot distinguish between dark green and light red, nor can they see a dark red letter on a black ground.

Here we can merely allude to cases of incomplete colour-blindness, the range of which may be indefinitely extended. It is unquestionable that the eye of the painter sees very differently from the eye of the average person who, relatively to the painter, certainly suffers from incomplete colour-blindness. When a lady complained to Turner that she could not see all those colours in the sunset, he replied, "Ah! madam, don't you wish you could?"

The Consequences of Colour-blindness. Colour-blindness is mainly a disease of the male sex. In all nations, about 3½ per cent. of the men are colour-blind. Now, red, green, and white are universally adopted as signals to indicate danger and safety, and these are just the colours which the colour-blind men mistake. On the other hand, other colours cannot be substituted for them, since they do not transmit nearly so much of the light behind them. Thus, it is necessary to exclude colour-blind men from such work as that of signalmen; and this is done by causing them to match coloured worsteds. In order to study the colour sense most perfectly, we should employ the pure spectral colours, and Lord Rayleigh, among others, constructed instruments for this purpose. The worsted test universally goes by the name of *Holmgren*, of Upsala, who was the first to employ it in a systematic way.

C. W. SALEEBY

Various Forms of Bonds. The Formation of Brick Walls. Bonding with Mixed Materials. Building and Bonding Curved Walls.

THE BONDING OF BRICKWORK

In any wall or structure not cut out of solid material, but formed of a multiplicity of parts, each of which is small in bulk compared with the wall into which it is built, it is inevitable that there must be many joints. Some of these are approximately or accurately horizontal, and some are approximately or accurately vertical. The horizontal joint may extend through the whole thickness and length of the structure, if the portions of which it is built be of uniform size and have horizontal surfaces, and this condition is met with in all brick walls. The layer of materials placed between two such level surfaces is termed a *course*. Where the size of the block is not regular, even when the beds are horizontal, the horizontal joints may not be found continuously at the same level, and this condition is met with in some forms of stone walling. [See MASONRY.] Unless some provision is made to prevent it, there is a danger that the vertical joints, like the horizontal ones, may continue throughout the wall from base to top, and while a level horizontal course is an advantage in constructing walls, a vertical joint extending through more than a single course is termed a *straight joint*, and is a source of weakness.

Effect of Straight Joints. If such straight joints extend from top to bottom of a wall, we should have, in fact, a series of small piers placed side by side having no connection with the pier on either side, except the mortar joint [41 and 42]. If such a pier is subjected to a load that is different from the load on the pier on either side, it may be thrust out of the line of the wall, or it may be crushed if not strong enough by itself to carry such load, or it may be caused to subside.

It is of equal importance that there should not be a straight joint in the cross-section of the wall, for if no alteration be made in planning the successive courses, a thick wall, such as that shown in 45, would be, in fact, formed of two thin walls placed side by side, and a load that was borne on the inner half of the wall would convey none of its pressure to the outer half, and might settle down under the burden by itself, whereas a wall that is properly bonded in cross-section [44] will have any load that bears on a given point distributed throughout its thickness as well as along its length.

Bonding, which is used to prevent such a form of construction, is the placing of the vertical joints in every course so that they shall not, except where it is inevitable, coincide with the vertical joints in the course immediately below it. The result of such an arrangement is that the materials in one course interlock with those in the courses above and below it. A wall is thus formed which no longer consists of independent piers, but is homogeneous in character, and the burden of a load supported at any one part of it is distributed by successive courses over an ever widening area [43].

Brick Bond. It is necessary to bear in mind that the bricks of any one class of manufacture are practically identical in size and shape, and that any trifling irregularities can be corrected by an adjustment of the thickness of the mortar joint. In building, therefore, with materials that are uniform in size and of such a shape that two of them, laid flat and side by side, form a nearly exact square, straight joints are very liable to occur if the work is carelessly put together; but, on the other hand, a comparatively simple adjustment, if properly carried out, suffices to obviate the danger entirely.

There are various methods of making the necessary adjustments, and various methods of arranging the bricks in a wall, and in particular on the face of the wall. Where differences in arrangements of the bricks affect the appearance of the wall, the terms applied to different varieties of walling depend on the style of bond in which they are built.

Forms of Brick for Bonding. Before describing the various forms and methods of bonding, a few general terms must be made clear. A *bat* is half of a brick broken across its length. Usually, bricks are broken so as to be one quarter and three quarters in length, or each one half, and are described as quarter bats, half bats, or three-quarter bats [10 and 11, page 2456]. They may be cut with the trowel from a whole brick, but in the process of carting, unloading, and stacking bricks, some always get broken, and these are utilised for such purposes, and can be cut if required to any requisite length. A *closer* is a brick cut in half in a direction parallel to its length, called a *queen closer* [6, page 2456], or so as to show a width of 2¼ in. on the face of the wall, and the full width of 4½ in. at the back, called a *king closer* [5 and 9, page 2456]. In practice, a queen closer is difficult to cut, and is not often specially moulded; two quarter bats are generally used in place of it. [See dotted lines 6, page 2456.] A brick placed in a wall so that one of its long sides shows on the face of the wall is called a *stretcher* [38]; and a course consisting entirely of bricks so placed is called a *stretcher course* [38, course 1]. A brick placed so that one of its ends shows on the face is called a *header*, and a course consisting entirely of such bricks is called a *header course* [38, course 2].

Describing Thicknesses of Walls. The thicknesses of a wall may be described by the number of headers contained in its total

thickness—thus, a one-brick, two-brick, three-brick wall, etc.; if the wall be only a half-brick thick, or is a multiple of a half-brick in thickness, it may be described as a one-and-a-half brick, two-and-a-half brick wall, etc. The convenience of this description is that it satisfactorily describes the wall for all types of bricks, not only for the ordinary sized brick [1, page 2456], but for bricks that may run a little larger or smaller. The thickness of a wall may also be described by the number of inches in its thickness—thus, a $4\frac{1}{2}$ in. wall = a half-brick wall; a 9 in. wall = a one-brick wall. A brick-and-a-half wall is sometimes spoken of as a $13\frac{1}{2}$ in., and sometimes as a 14 in. wall, for by using a thick mortar joint in the thickness of the wall it may be brought up to this larger dimension. An 18 in. wall = a two-brick, and so on; but this description is only accurate when bricks of the ordinary standard size are being employed.

English Bond. English bond, which, from a structural point of view, is the best for all ordinary walling when the thickness is one brick or upwards, is formed when, in elevation, every course is either a complete header course or a complete stretcher course [38]. Stretchers are never used in the interior of a thick wall, but only on the inner or outer face of such a wall. When the thickness of the wall is the exact multiple of a brick, each course will show alike on the inner and outer face of the wall—*i.e.*, either both sides will show headers or both stretchers. [See examples of one-brick and two-brick walls in 38]. If there be an odd half brick in the thickness of the wall, the course that shows stretchers on the outer face will show headers on the inner face, and vice versâ. [See one-and-a-half and two-and-a-half brick wall in 38.] When a wall is returned at the end—that is to say, is continued in a direction at right angles to its former direction—the course that shows stretchers on the main front will show headers on the return front, and vice versâ.

Finishing Ends of Walls. All the plans on the general sheet of bonding show walls which on the left-hand side have returned ends, and it will be noticed that in every case course 1 has closers inserted next the angle brick to bond the return wall, and in course 2 has closers inserted next the angle brick in that course to bond the front wall. It will, of course, be understood that the angle brick in course 1 ranks as a stretcher so far as the front wall is concerned, but is a header if considered in relation to the return wall.

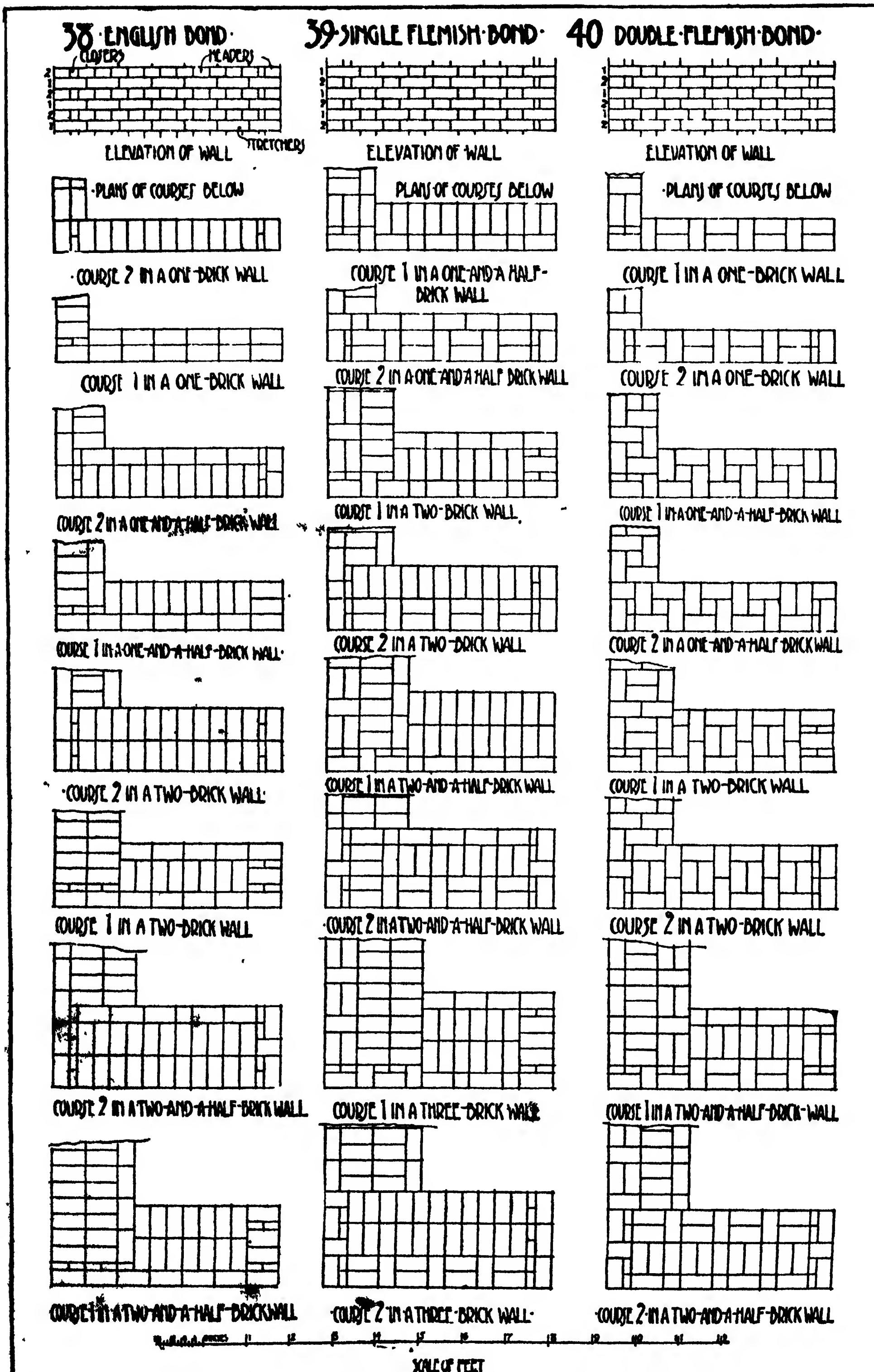
On the right-hand side of each plan the wall is shown to have a *stopped end*—that is, the wall is finished there without any return or reveal. All such ends require special attention to secure a satisfactory finish and perfect bonding.

Laying the Stretcher Course. We shall now consider the bonding of a wall which is an exact multiple of a brick in thickness, and commence with the stretcher course [38, course 1]. Such a course, whether the wall be one, two, three, or any other multiple of a brick thick, will have a row of stretchers extending from end to end on the outer face, and a similar row on the inner face. If the wall be one brick thick these two rows will complete the course, and the bricks in them should lie exactly side by side, so that the joints which run from back to front of the wall run straight through from face to face without any break in their length. If the wall be a two-brick wall there will be one row of headers in the interior of the wall separating the stretchers; if it be a three-brick wall there will be two such rows of headers, and so on. But note that in all cases the headers are laid so that two are placed exactly behind a stretcher, and, whatever the thickness of the wall, the joints that run from front to back do so without any break. We shall assume for the moment that the length of our wall is an exact multiple of 9 in., and that it will therefore contain an exact number of header bricks. But, of course, this is not always the case. If our wall be not an exact multiple of a brick in thickness, but contain an odd half brick, the only difference will be that the row of stretchers on the inner face will be omitted, and a brick-and-a-half wall will have one row of stretchers on the face and one row of headers behind; a two-and-a-half brick wall, one row of stretchers and two rows of headers, and so on.

Laying the Header Course. If this course [38, course 2] consisted literally of nothing but headers, we should have a wall without bond [41]. It is in this course that the closers are introduced; but whatever the length of the wall, so long as there is no opening or return in it, there will never be more than two closers, one of which occurs at each end of the course. For the purpose of bonding, any interruption in the continuity of the brickwork, such as that due to the opening for a door or window, may be considered to divide a long wall up into a series of short lengths, each of which must be provided with the closers for bonding. In laying this course recollect that a header always forms the end brick.

The whole thickness of the wall in this course, if it be an exact multiple of a brick, is formed with headers, and for every brick in the thickness of the wall there will be a header in the plan. In this course, as in the stretcher course, the joints at right angles to the face will run straight through from back to front in an unbroken line. If there be an odd half brick in the thickness of the wall a stretcher course is employed on the inner face.

Position of the Closer. The closer should never form the angle brick, for as it is only $2\frac{1}{4}$ in. wide, it would be very liable to become dislodged, but it must always form the next brick to the angle header. It should extend right through the thickness of the wall to be bonded from the front to the back. Theoretically, a queen closer should be used for every header in the thickness of the wall, but in practice, except for work of quite an exceptional character, two quarter-bats are used to form the closer for each brick in thickness. It will be seen [43] that the width of the angle header ($4\frac{1}{2}$ in.) plus the width of the closer ($2\frac{1}{4}$ in.) make together $6\frac{3}{4}$ in., which leaves $2\frac{1}{4}$ in. between this vertical joint and the first joint in the course below, and that as the face of the next header



38–40. EXAMPLES OF BRICK BOND FOR WALLS

is $4\frac{1}{2}$ in., the vertical joint beyond it will also be $2\frac{1}{4}$ in. beyond the first vertical joint in the stretcher course. This horizontal distance is termed *lap*. Beyond this point, as two headers together equal in width one stretcher, the same distance between the vertical joints in the header and stretcher course will be maintained till the other end of the wall is reached, and the closer at that end is inserted to give a corresponding break and finish to the wall. A wall, whatever its height, will consist entirely of successive courses, in which the two above described will alternate regularly.

Adjusting Bond to Walls of Various Lengths. We assumed for the moment that the length of our wall was an exact multiple of a brick in length; but this may not always be the case. Suppose there be an odd half brick in the length, the only adjustment required will be that at or near the centre of every stretcher course a half-bat be inserted [46]. In building with such a material as brick, if good and economical work be required, the limitations it imposes must be considered, and no short length of brick wall should be set out except as a multiple of a half-brick in length as well as thickness. In the case of a long wall this point is not of importance; in such a wall there will be so many vertical joints that by a little *fulness*—*i.e.*, an extra amount of mortar—in the joint, or a little *tightness*—*i.e.*, a reduced amount of mortar—in the joint, some definite number of headers may be worked into its length.

Absence of Straight Joints in English Bond. In the case of a wall constructed in English bond [38], if the plans of the two courses of any wall be traced and placed one above another, it will be noticed that if queen closers are used there will be no position either on the face or in the heart or thickness of the wall in which the vertical joints in one course coincide with the vertical joints in the course below. If quarter-bats be used in place of queen closers such coincidence will exist only where the extra joints thus introduced occur. Such a coincidence, as already explained, forms a straight joint, and if it occurs in two successive joints, note that it will run throughout the whole height of the wall inevitably. It is the absence of these straight joints that renders English bond of such great structural utility as a more homogeneous wall is obtained when it is used than in the case of other bonds.

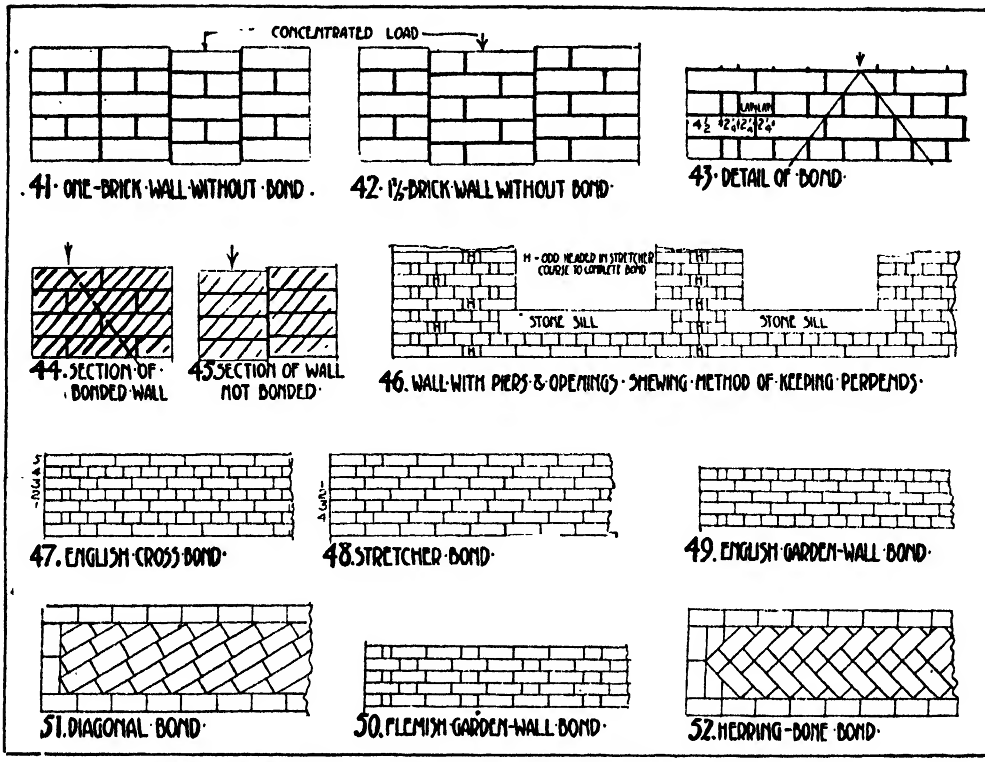
Other Styles of Bonding. On the other hand, in elevation the appearance of successive rows of headers and stretchers is considered less attractive than some other forms of bond, and where, as in the case of much domestic work, the utmost possible strength is not essential, and something may be sacrificed to appearance, a style of bond which is not quite so satisfactory structurally, but gives a different character to the face of the wall, is adopted. With a view to improving the elevation, a variation of this style of bond, known as *English cross-bond*, is sometimes adopted [47]. As will be seen, the only variation consists in breaking the bond between successive stretcher courses by introducing next the angle stretcher (in course 3) a single header, or bat, so that beyond this point the stretchers in this course are shifted $4\frac{1}{2}$ in. to the right, and come over the centre of the stretchers in course 1. This must, of course, be provided at each end of the wall. Course 5 repeats course 1, and course 7 repeats course 3, and so on. No change is made in the header courses, and this particular bond is not inferior to English bond in strength.

Flemish Bond. Flemish bond is made use of as a further improvement to the elevation of the wall; it differs from English in elevation in that each course consists of a header and a stretcher alternating, and at the end of a wall we find in one course a stretcher forming the end brick, and in the succeeding course a header at the end. There is not the same simplicity as to the placing of the bricks in the wall as occurs in English bond, and the number of straight joints are considerable, especially when there is an odd half-brick in the thickness of the wall. In the case of a one-brick wall the same bond must show in both faces; in the case of thicker walls it may do so; but, on the other hand, the use of Flemish bond may be confined to the outer face of the wall and the inner face, and the heart of the wall may be formed in English bond, to which there can be no objection if, as often happens, the inner face is to be plastered. When this form of bond is used throughout the thickness of the wall, and shows on both faces [40], it is termed *Double Flemish Bond*; when used on one face only [39], it is termed *Single Flemish Bond.*

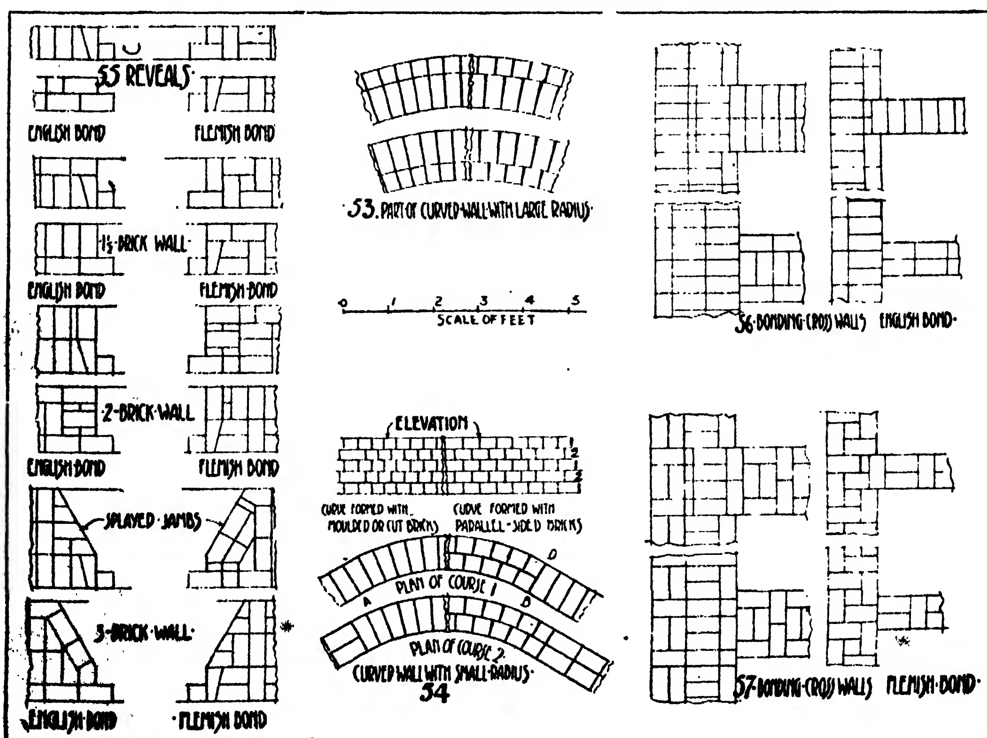
In this bond, as in the English bond, the closer is placed in the course which begins with a header at the end angle. This closer is carried right through the thickness of the wall; but where a header shows in the return end, or face, to avoid using a half-bat and quarter-bat, a three-quarter bat is used, by which the same result is achieved with the saving of one joint. The sources of weakness in this form of bond are the large proportion of bats that are inevitable wherever the thickness of the wall has an odd half-brick in it when double Flemish bond is used [see one-and-a-half and two-and-a-half brick walls, 40], and where the thickness is the multiple of a whole brick where single Flemish bond is used. [See two-brick and three-brick walls, 39.] This is partly due to this use of bats, but mainly to the use of stretchers in every course; if tracings of the plans of two successive courses of Flemish bond be overlaid, it will be found that, to a very appreciable extent, they coincide throughout the whole length of the wall, and that straight joints result. It is on this ground that, where possible, single Flemish bond is adopted, as this confines the use of bats and straight joints to the outer face of the wall.

One of these two forms of bond is used for most ordinary walling. There are other varieties of bond, but they are mainly required to meet difficulties that arise under certain exceptional conditions.

Stretcher Bond. Stretcher bond [48] is used for walls that are only half a brick in



41-52. EXAMPLES OF UNBONDED WALLS AND SPECIAL FORMS OF BOND



53-57. BONDING OF OPENINGS AND OF CURVED AND CROSS WALLS

thickness. It is obvious that headers, which are 9 in. long, cannot be used in such a wall, and if any appear in the wall, they are only bats. This bond, it will be seen, consists of building entirely with stretchers; it is usually built of only two varieties of courses—*viz.*, 1 and 4 [48]; but more complete bonding is produced by using the four varieties shown.

This wall, by using a large proportion of bats, might be made to resemble Flemish bond; but the only occasion in which the appearance of the wall would be of sufficient importance to warrant this would be in the case of a half-brick wall formed of glazed bricks.

Garden-wall Bond. Garden-wall bond is used for 9 in. or one-brick walls, in which both faces are exposed to view. These are commonly used for separating the gardens of adjoining houses, hence the name. The difficulty met with in such walls is that though the length of an ordinary brick is given as 9 in., there is a considerable variation in practice in this length, not, perhaps, more than ⅛ of an inch, more or less, but enough to make it impossible to set such bricks side by side in a wall so that both faces will be true. If one face is to be plastered, this is not important; the outer face is built even, or "fair," and if the inner is rough the plaster covers it. Adjustment can be made between stretchers, because there is a mortar joint between them, which may be made "full" or tight, as the case requires.

It is therefore necessary to pick over the bricks to be used as headers in such a wall, and to measure them against a standard length of brick, and this process means additional handling and cost. This form of bond is used in this case because it reduces the number of headers by 50 per cent. It may be employed both with English and Flemish bond. *English garden-wall bond* consists in using three stretcher courses to one course of headers [49]. This involves a straight joint in the centre of the wall through the stretcher courses, and this is undoubtedly a source of weakness, but such walls rarely support a heavy load. *Flemish garden-wall bond* consists in using three stretchers to one header in every course [50], and has the same advantages and drawbacks as English bond. Such work requires careful supervision, for even with selected headers there is often slight irregularity or distortion, and to give a good finish to the face the bricklayer is apt to cut the header into two, making it easier to set fair, but still further reducing the strength.

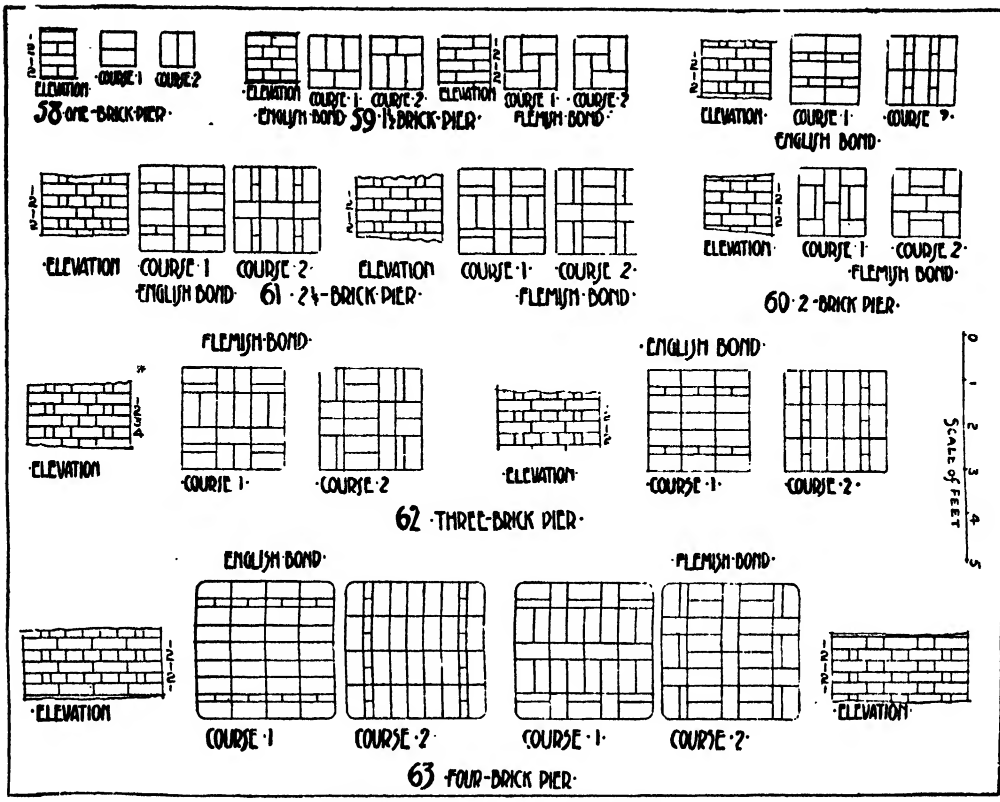
Diagonal Bond. Diagonal bond is used principally in thick walls to give a longitudinal bond at intervals. It does not show on the face of the wall; it is most satisfactorily used in the stretcher course of English bond, and is not employed in every such course, but at intervals of, say, six or eight courses. It consists in filling in the heart of the wall with bricks laid diagonally, as shown in 51. The small triangular spaces between the facing and the diagonal work are filled with pieces of brick, roughly cut, and mortar. The bricks shown here are inclined from left to right. The next time that such a course was used they should be laid with an inclination from right to left, so as to vary the bond as much as possible.

Herringbone Bond. Herringbone bond is used in the same way as diagonal bond, and with the same object, the only difference being that the filling in is arranged on plan in the form known as *herringbone* work [52].

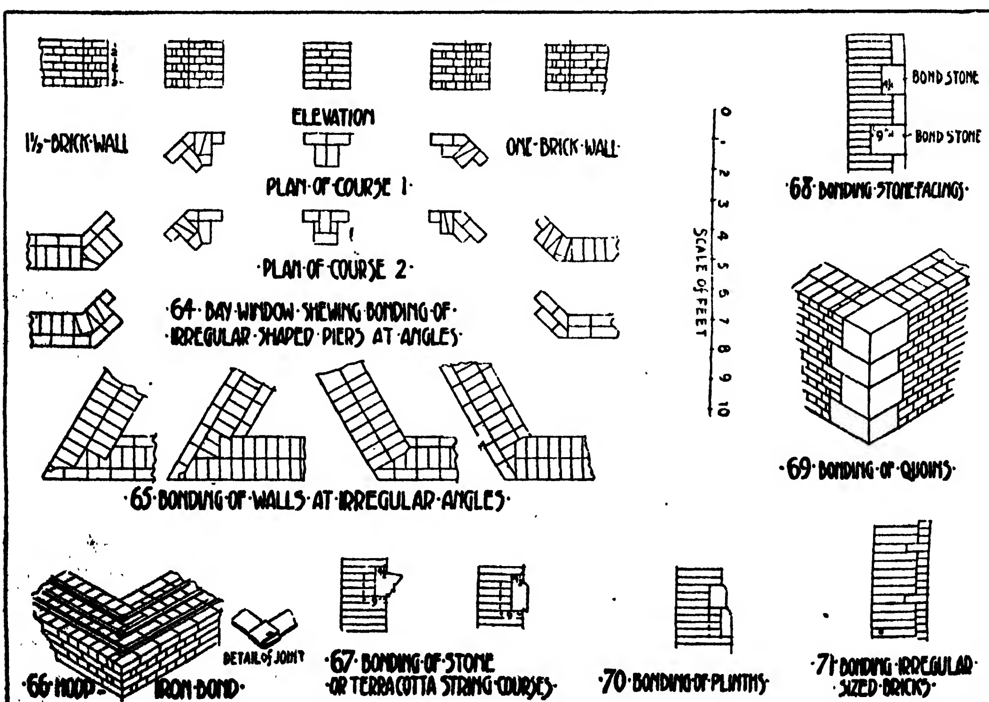
Walls Built Circular on Plan. The work hitherto described is adapted to walls that are built in straight lines, but sometimes walls must be laid on a plan that is not straight but curved. If the radius be large, and the curvature in consequence flat, the wall may possibly be built with one of the bonds already dealt with; but if the radius be short, and the curve rapid, this will be impossible.

In such a case the ideal plan is, of course, to have bricks that are purposely made with the faces formed to the required curve and the sides of the bricks converging so as to form what in an arch would be called a *voussoir-shaped brick.* This is costly; and for most work a sufficiently good appearance may be given by using ordinary bricks, provided only *headers* are employed. Such bricks will not form a true circle; but unless the radius of the curve is very small, the form will approach closely to a curve. It is essential that no stretchers be used and every course consist solely of headers; and the term *Header Bond* is applied to it. Such a piece of curved work rarely stands alone, and is used to connect two straight pieces of walling, and the bonding of the two courses is formed by continuing the bond already existing in the walls. Fig. 54 shows a wall quadrant on plan with a rather short radius, and 9 in. thick. It will be observed that the distance from A to B on the concave face of the wall is appreciably less than that from C to D at the back, and if ordinary parallel-sided bricks are used, the mortar joint must be kept fine on the face and full at the back to adjust this difference. Better work is produced by rough-cutting the brick to a *voussoir* shape, or by rubbing it accurately to such a shape, as shown on half the illustration; but this increases the cost. With the small radius illustrated the use of headers would require very wide joints at the back, and two courses of half-bats are shown. Bonding irons may be used to tie the inner and outer face together. Fig. 53 shows a wall one-and-a-half bricks thick, with a curve of a larger radius. In this case it will be noticed that either on the inner or outer face of this wall a row of bats is inevitable—with a curve of such large radius, very good work may be produced without cutting or rubbing the bricks—but the joints from front to back of the wall will not in this case be in a straight line. In this illustration the wall is shown formed on the right-hand side with parallel-sided bricks, and on the left with cut or rubbed bricks.

Forming Reveals. The method of forming stopped ends has been indicated, and we must now consider those cases in which a wall has to be finished with a *reveal.* This is a short return usually 4½ in. on the face, but sometimes 9 in. or more, which projects beyond the



58-63. BONDING OF BRICK PIERS



64-71. EXAMPLES OF IRREGULAR BONDING

end of the wall so as to form a rebated jamb, to allow of a door or window-frame being inserted behind it. Special attention must be paid to its bond, and it is in connection with this work that the king closer comes into service. The half-bat at the end of the header course is a source of weakness, and the use of the king closer next to it is some compensation. The methods of bonding reveals in ordinary walls of various thicknesses are shown [55] for both English and Flemish bond.

Bonding of Cross Walls. In addition to return walls, which have been already described, *cross walls* are frequently employed. These are walls starting from the internal face of the main wall at right angles, and they must be bonded to the main wall equally with a return wall. This is usually arranged for by building in the whole thickness of the cross wall at every alternate course to an extent of $2\frac{1}{4}$ in. into the main wall, the intermediate course of the cross wall merely abutting against the main wall [56 and 57].

Bonding of Piers. Piers intended to carry concentrated loads may be either attached to a wall or may stand alone and detached. In the former case the bond used in the wall will apply to the pier, and it will be treated as a short length of a thicker wall. So, also, in the case of a rectangular detached pier, it may be considered as a short length of wall with two stopped ends; but in the case of square piers a special treatment is usual, to secure proper bonding. Such piers may be constructed either in English or Flemish bond; the former is preferable where great strength is required. In all square piers the extent of closers required for bonding bears a larger proportion to the total area of the pier than in the case of a wall of the same actual area; in piers of less than three bricks this proportion becomes very excessive. It is an element of weakness in them, and all piers require very special care in construction to ensure that the joints are all well filled, and where Flemish bond is used queen closers should be employed and not quarter-bats. A pier one brick square can be formed only of two stretchers in one course and two headers in the next [58]. A pier one and a half brick square may be formed in English bond with two three-quarter bats alternating with three headers, but some extent of straight joint is unavoidable [59]. With Flemish bond it is necessary to use a bat as a core or centre for all courses, and a straight joint occurs all around it. With piers two bricks square and upwards the bonding is more satisfactory. Examples are shown of piers in both styles of bond up to four bricks square; one pier [63] is shown formed with bull-nosed bricks at all four angles. Various examples are given of the method of bonding various small and irregular shaped piers such as occur in the angles of bay windows [64] and similar situations; they should be constructed in cement mortar, to secure the utmost possible strength, as in the case of small piers, they involve the use of a large proportion of bats and of irregular piece of brick. Such piers, as a rule, are of no great height, and cannot be expected to carry anything but quite a light load.

There are many situations in which a return wall is not at right angles to the front wall. When this is the case it is termed a *squint* angle, which may be either acute or obtuse. Here, also, special attention must be paid to the bonding, and no regular rules can be given for the construction of such angles, as the methods vary with the inclination between the two walls. Examples of such angles are given [65], and it is important to bear in mind that as few small pieces of brick as possible should be used. Whole bricks, wherever possible, or bricks with only the angles cut off, are the best. In the case of obtuse angle walls squint bricks [7, page 2456], of which the longer side is $6\frac{3}{4}$ in., may often be used in place of using closers, and, when possible, this is advantageous. A bird's mouth [8, page 2456] is often also useful for the inner face of an obtuse angle, but such bricks are not easy to cut, as the small angles may be split off. It is advisable, when possible, to dispense with their use.

Hoop-iron Bond. Hoop-iron bond is sometimes introduced into walls to give a bond or tie in the direction of the length. But in walls built with cement mortar it is doubtful if it adds to the strength of the wall materially. It consists of strips of hoop iron about $1\frac{1}{2}$ in. broad and $\frac{1}{20}$ in. thick, which, unless they are laid in cement mortar, should be tarred and sanded to protect them, and in order that the mortar may grip them. It is usual to insert the hoop iron in the mortar joints at certain definite intervals throughout the height of a wall varying from, say, four courses apart to 4 ft. or 5 ft. Each course in which they are used may have several strips of iron. If a joint has to be made in the length of the iron strip a lapped joint is used, and a similar joint is made at the angle of a wall, the two pieces being crossed and the end folded down [66]. Hoop iron bond is used in the construction of burglar-proof vaults, and for this purpose hoop iron is laid in every joint, and one strip is used for each half brick in the thickness of the wall, which is built of hard bricks in cement. It is claimed that a structure thus formed will resist even a determined attempt to penetrate it.

Bonding of Facings. It frequently happens, when the appearance of the exterior of a building is a matter of importance, that the bricks used for the face are required to be of a different quality and appearance from those used in the thickness of the wall, and in consequence may be more costly. In bonding such facings with the heart of the wall, if the bricks correspond in size with those used in the general body of the work, the bonding should be carried out exactly as already described for a wall of a uniform quality. The great danger to be feared is that, with a view to economy, half-bats may be employed where headers should be used; for as a true header can be broken into two bats, fewer of the more expensive bricks will be required when this is done; but if this plan is

largely adopted the facing becomes a mere skin of brickwork a half-brick in thickness, instead of being, as it should be, an integral part of the wall. It may sometimes happen that the size of the facing bricks differs from that of the bulk of the bricks. When this is the case, really satisfactory bonding cannot occur, and such a condition must always be avoided if possible. For example, seven courses of facing bricks may be equal in height to six courses of the general work [71]. If this be so, the joints will only correspond so as to form a true horizontal bed at every seventh course of the facings, and all that can be done is to introduce a course of headers at this point, and to build the courses up to the next level bed in stretcher bond.

Bonding Brick with Other Materials. The bonding described hitherto has referred to walls constructed wholly of brick. It frequently happens that for architectural effect, or for some other reason, part of the wall may be formed of other material, as, for example, terra-cotta or stonework. These materials may be introduced merely in the form of plinths, strings, and cornices (67, 70] at quoins [69], and round door and window openings—such work is described under the general term of *dressings*—or it may be used throughout the face of the wall [68]. In the latter case it may form merely a facing, the bulk of the wall being of brick, or the facing material may form the bulk of the wall, with merely an inner lining of brick to take the plastering. This last case, however, arises, as a rule, only when the material employed is of a rough character.

Brickwork and Terra-cotta. The bonding of brick with other materials may be a comparatively simple or a troublesome and costly process. Which it is to be will depend on the care given in preparing the material to be bonded with the bricks. The bricks are of a stock size; and if the work is to be easy in character this must be borne in mind, so that they can be utilised without cutting to any great extent. If terra-cotta be used, it must be specially manufactured for each building in which it is employed; if in moulding care must be taken to see that the height of each course with its mortar joint corresponds exactly with one or more brick courses with their mortar joints, and if the beds are also exact multiples in length and breadth of a half-brick, the whole will bond together with ease. But if this be neglected, the terra-cotta, after it is burnt, must not be cut; and if the bricks have to be cut to fit it, this involves considerable labour.

Brickwork and Stone. In the case of stone it is usual, except for rubble walls [see MASONRY], to dress the stone—*i.e.*, to reduce it to a fair face and to exact dimensions, and such stones can therefore usually be made of a size to bond with brickwork without any increase whatever in the cost of working. In the case of dressings, a string, of which the mouldings have only a slight projection, may be, for example, so designed as to correspond in height with two courses, and on bed to equal a half-brick in width from front to back, with here and there a block of material equal to a whole brick [67]. In the case of quoins, whether plain or moulded, these may vary in height from one up to five or six courses [69], or even more, and they are usually arranged so that the widths of successive courses vary by the multiple of a quarter-brick to assist in bonding. It is an easy matter to cut the end off a brick to fit any quoin; but if the thickness or breadth of a course will not bond it may involve the reduction, by cutting, of a whole course of bricks.

Stone-faced Walls. Where a wall is to be faced with stone or terra-cotta the work is usually described as *ashlar* [see MASONRY], which implies that the stones or blocks are of regular height, length, and breadth, with a regularly dressed face. Such a facing may, of course, be made of any desired thickness, but, on the ground of expense, is often kept thin. The majority of the stones will be of the minimum thickness, but a certain proportion, equal to, say, one-third or one-fourth the area of the face of the wall, will be made thicker, so as to penetrate into the brick backing, and tie the backing and facing together. The difference between this thin and the thick courses should be half a brick or a multiple of half a brick.

In roughly built stone walls, such as rubble walls, the bulk of the wall is of stone, and if brick is used it will generally be in the main a half-brick thick, with a certain proportion of headers built into the wall, either in regular courses or as found convenient, but these should not be less than about one-fourth of the bricks.

Sometimes a flint-faced wall, if of knapped flints [see MASONRY], may be built as a facing to a brick wall, and in such a case the bond is usually secured by building in a proportion of extra long flints, so that they penetrate into the brickwork; but sometimes a small proportion of black, vitrified bricks may be used as headers, extending to the outer face of the flint to assist the bond.

Reinforced Brickwork. Brickwork is capable of reinforcement, and this is of special utility in thin walls. Half-brick and even brick in edge walls may thus be rendered very much stronger and more rigid. One form of such reinforcement consists of four or five strands of mild steel wire running continuously with cross wires forming a mesh, the total width being 2 or 2½ inches. This is supplied in long rolls, and is laid in each mortar joint, and is imbedded in the mortar, which should be of Portland cement and sound. Such reinforcement gives great lateral strength, great transverse stiffness, and is serviceable in forming thin partitions and cavity walls.

R. ELSEY SMITH

The Evolution of Birds. Birds that have ceased to Exist.
The Reckless Destruction of Birds. Changes taking place now.

THE FUTURE OF BIRD LIFE

IN the course of animal evolution there seems to have been a frequent bifurcation into more active and more sluggish types, and there is no doubt that a cleavage of this sort occurred very early in the evolution of birds. The one alternative is represented by the flying birds, or Carinatæ, and the running birds, or Ratitæ, the names referring to the conspicuous feature that the keel, or carina, on the breastbone of flying birds, which affords attachment to some of the muscles of flight, is not developed on the raft-like breastbone of running birds. There are, of course, a great many other differences, for the divergence of the two great orders, or divisions, was very thoroughgoing.

Running Birds. The Ratitæ were established in the Miocene Ages, if not in the Eocene, and, though never very successful, they had a cosmopolitan representation. With their flightless, thoroughly terrestrial habits we may connect not only the character of the breastbone, but the more or less degenerate characters of the shoulder-bones and fore limb. The feathers of the adults have free barbs, and the barbules have no hooks. Their skull is of a type that never occurs among the flying birds, with the single exception of the tinamou.

It is maintained by some authorities that the existing Ratitæ are descended from forms that could fly, but the evidence of this is not quite convincing. It seems not unlikely that they represent a primitive stock that never attained to flight, and they certainly carry marks of primitiveness in many different parts of their body. We may notice the absence of regularly arranged feather tracts, the absence of a ploughshare bone at the end of the tail, the absence or small size of hook-like (uncinate) processes on the ribs, the compound character of the horny bill, and the fact that the junctions, or sutures, of the skull-bones remain for a long time distinct, whereas in flying birds they almost always disappear very early.

W. K. Parker spoke of the Ratitæ as "overgrown, degenerate birds that were once on the right road for becoming flying fowl, but, through greediness or idleness, never reached the 'goal'—went back, indeed, and lost their sternal keel, and almost lost their unexercised wings." We may think of them as illustrating arrested development—the persistence of numerous primitive and also juvenile features.

The broad fact about them is that they have not been successful as compared with the Carinatæ. The giant *Æpyornis* of Madagascar has long since gone; the giant moas (*Dinornis*) of New Zealand have also disappeared; and there are only five living types—the African ostrich (*Struthio*), the South American ostrich (*Rhea*), the Australian emeu (*Dromæus*), the Austro-Malayan cassowaries (*Casuarius*), and the small kiwis (*Apteryx*) of New Zealand. The persistence of two of these—the American ostrich and the kiwi—is seriously threatened. It seems as if flightless terrestrial birds were condemned in the struggle for existence as a sort of contradiction in terms.

Carinate Birds. At the time when *Hesperornis* swam about in Cretaceous seas, there was another toothed bird, *Ichthyornis victor*, hardly less remarkable. [See PALÆONTOLOGY in GEOLOGY.] It was a small bird, towards a foot in height, and delicately built; it had a strong keel and well-developed wings. The teeth were fixed in distinct sockets and the vertebræ were biconcave—two very striking features, which point back to reptiles. Of its affinities, Mr. Pycraft says cautiously, "Ichthyornis may perhaps be, and generally is, regarded as the ancestral type of the present Steganopodes—the gannets, cormorants, pelicans, tropic and frigate birds."

The fossil record leads us to the conclusion that the running birds and the flying birds diverged at a very ancient date, and it is very striking that in Cretaceous times there should have existed such birds as *Hesperornis*, which is extremely specialised for aquatic life, and *Ichthyornis*, which, apart from its teeth and vertebræ, "had acquired all the characteristic peculiarities of the class Aves."

The Specialised Adaptation of Birds. What, then, has happened among birds in the long interval of time since Cretaceous ages? The general answer, we think, must be this—that there has been an extraordinary amount of specialised adaptation and perfecting of detail, but no new departure of great importance.

It is not difficult to see the general reason for this, which an analogy may illustrate. When a piece of mechanism has become very complex, its range of evolutionary progress is restricted within narrow limits. It may be improved in detail in this corner and that, but it is not likely to undergo any great change. It is no longer open to any important modification in principle. The compound microscope of today, with its new glass and fine adjustments, is an improvement on that of fifty years ago, but there has been no fundamental change. When a highly evolved piece of mechanism seems to undergo a fundamental change, there is some discontinuity in the evolutionary process; though the outer framework sometimes remains more or less the same, there has been a thoroughgoing internal reorganisation in obedience to a new idea. The motor-bicycle is not an evolved bicycle, nor is a Zeppelin an evolved aeroplane. Returning to the first known flying birds, we

recognise that they were already exceedingly complex, with much of their constitution definitely adapted to the successful solution of a very difficult problem—that of flight. We can understand why they have not given rise to any other kind of creature, even in the course of millions of years. They have simply given rise to birds and birds, endlessly adapted to particular conditions of life.

It is among primitive, undifferentiated types that we must look for important new departures. From an early date the bird's whole organisation was so thoroughly adapted for flight that no big change was possible, unless, indeed, at the risk, which the penguins well illustrate, of losing the great secret of flight again. What has actually happened has been the evolution of a large number of orders, and within these there has been an embarrassing detail of specialisation to particular haunts and habits.

Evolutionary Possibilities Open to Birds. If we cannot expect birds to give origin to any different kind of creature, what other evolutionary changes are open? As an answer we may state the following four directions in which evolution may trend. In the first place, what has been going on for untold ages may continue. There is the possibility of increasingly minute and specialised adaptation of structure. In the order of perching birds, or Passeres, there have evolved in the past hundreds of closely related species, each adapted to its own particular "niche of organic opportunity," and accordingly it may be that new species will go on appearing in this and in other orders. Secondly, there is the possibility of great increase in intelligence, of brain improvement, similar to that which marks off man from the other primates. In rooks, cranes, and parrots we get a glimpse of the intellectual possibilities of birds.

Thirdly, there is the possibility of larger changes in general constitution and habits, such as we see in burrowing birds, and this involves the risk of losing the secret of flight—a risk proportionate to the amount of divergence from the ordinary type. There is, lastly, also the possibility that the species of birds now existing may suffer reduction in numbers. In many cases this is already a probability, and we know that many birds that once flourished are now extinct. We shall briefly refer to birds that have disappeared or are disappearing.

Extinction in Ancient Times. Referring first for a moment to the fossil birds, we must recall the important distinction between "lost races," which have left no modern representatives, and the "extinct ancestors" of living birds. It may be that some of the Odontolcæ were ancestral to our modern divers, but there is no reason to believe that the highly specialised *Hesperornis* has any lineal descendants today. The same may be said of the giant moas and *Æpyornis*. It is impossible to give any general answer to the question, "Why have these splendid types perished?" except the familiar one, "Elimination in the struggle for existence," and this is apt to be somewhat platitudinarian in regard to distant ages whose conditions of life are very vaguely known. A pioneer like *Archæopteryx* was very far from being perfect as a flier, and the survival of birds that could not fly at all would be obviously imperilled when mammals appeared on the scene.

THE WEIRD BIRDS OF PAST AGES

Extinction in Recent Times. The dodo (*Didus ineptus*), a "ponderous pigeon," was found inhabiting Mauritius when that island was rediscovered by the Dutch at the end of the sixteenth century. "Clumsy, flightless, and defenceless, it soon succumbed, not so much to the human invaders of its realm as to the domestic beasts—especially hogs—which accompanied them" (Prof. Alfred Newton). There is no evidence of its survival after 1681. There was

an allied bird in the adjacent island of Réunion, and another, the solitaire, in Rodriguez, both of which disappeared with the dodo.

Besides the dodo, Mauritius has lost at least two parrots, a dove, a large coot, and a long-billed flightless rail called *Aphanapteryx;* Réunion has lost a peculiar starling and other birds; Rodriguez has lost an owl, a parrot, a dove, a heron, a rail, and, indeed, most of its original bird tenantry. The same is true of other islands, but it is not within our present scope to pursue the subject further. It is enough to point out that there are several reasons why comparatively small islands afford so many instances of extermination: the advent of man and the introduction of new mammals must have a more pronounced effect in a circumscribed area; fires are apt to bring about wholesale destruction; and escape is more difficult than from a continent. For a flightless bird, like the dodo, escape from destruction was obviously impossible.

KAKAPO OR OWL-PARROT

The Great Auk. One of the best known of comparatively recent exterminations is that of the gare-fowl, or great auk (*Alca impennis*), a relative of our common guillemots and razorbills. It used to be abundant in northern seas, especially round Newfoundland, and was much used as food by sailors, just as penguins are sometimes used today in the far south. Colony after colony seem to have dwindled, and the species seems to have become extinct about 1844, "in which year the last two examples known to have lived were taken on a rocky islet—one of a group called Fuglaskér, or Fowl-skerries, off the south-west point of Iceland."

The great auk was a truly British bird, though nowhere abundant. It used to breed on St. Kilda, where one of the last specimens was taken in 1821. Another, perhaps the very last, was captured alive in Waterford Harbour in 1834. The reason for its extermination must be found, on the one hand, in its reduced wings, which were useless for flight, in its apparent stupidity, in its localised breeding-grounds, and in its slow rate of reproduction; and, on the other hand, in the fact that its feathers and its flesh were useful to man, who was, as in many other cases, short-sighted in his greedy persecution.

The Labrador Duck. Another striking case is that of the Labrador duck, or pied duck (*Somateria labradoria*), which used to be extremely abundant on the North American Atlantic coast from the mouth of the St. Lawrence to New England, nesting, like its near relative, the eider-duck, on rocky islands, safe from most possibilities of molestation. There is no certain record of it since 1852.

Four skins and a few bones are all that remain of a fine cormorant from Behring Island, in the North Pacific; perhaps a dozen museum specimens represent an interesting Nestor parrot (*N. productus*), from Phillip Island, off New Zealand; half a dozen museums can boast a specimen of the mamo (*Drepanis pacifica*), of the Sandwich Islands, a victim to its gorgeous yellow feathers, which were used to decorate the state robes of the chiefs; and we may close—without attempting to complete—the sad list by noting that only one specimen is known of Latham's white-winged sandpiper. We have given instances to show how the list has been reduced within comparatively recent times.

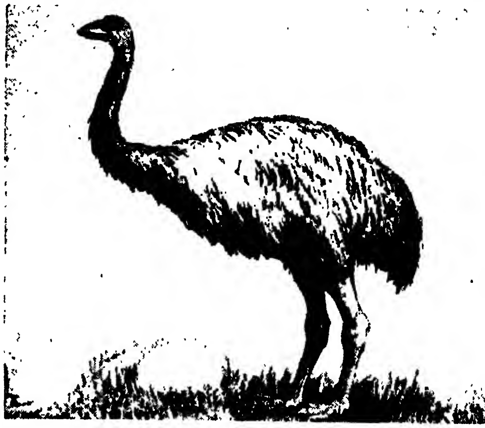
Causes of Extermination. In considering the causes of extermination we must in fairness remember that, altogether apart from the ruthless persecution on man's part, birds may be forced to relinquish their old quarters because human habitations and cultivations encroach on wild nature. It seems that good forestry diminishes the number of birds in the woods. As the English fen-country was opened up and restricted, the crane ceased to breed there, and the bustard became rarer on the downs as the arable land crept nearer.

Doubtless, in these two cases there was also persecution of the birds, especially at the breeding season, but the changes in the condition of the country must be borne in mind. As the indigenous pine-woods were more and more restricted in Scotland, the capercaillie disappeared, probably by the end of the eighteenth century; where it has been re-introduced and protected it has flourished and increased.

Another cause of extermination is game-preserving, for in its interests there has been a persistent and effective destruction of birds of prey. This is lamentable, not only because of the disappearance of handsome and interesting birds, but also because their removal affords opportunity to mice and voles and other destructive pests. We must, of course, dis-

VICTIMS OF THE ADVANCE OF CIVILISATION

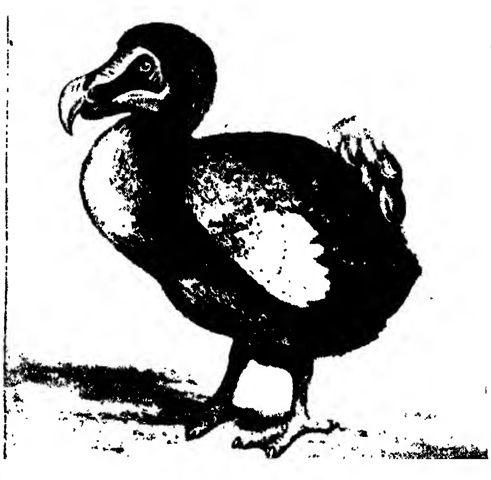
PHILLIP ISLAND PARROT



THE AEPYORNIS AND ITS EGG

THE GREAT AUK

THE SOLITAIRE



THE DODO

BIRDS OF THE EARLY DAYS OF THE WORLD THAT HAVE NOW BECOME EXTINCT

criminate, as fuller knowledge may enable us to do before it is altogether too late, between species like the sparrow-hawk, which destroy large numbers of young birds (apart from game), and species like the kestrel, which keep chiefly to mice and the like.

Bird Life Destroyed by Human Vanity. Another factor in extermination is the debasing fashion of wearing the plumage of wild birds as part of the dress, either for warmth, as in the case of feather boas and the like, or for decorative purposes. We must be precise in our judgment, finding nothing to be said against the use of feathers cut painlessly from ostriches, finding everything to be said against the use of "egrets," or so-called "ospreys"—tufts of filiform feathers which spring from the back of a white heron. "They are assumed only just before the breeding season, and hence the procuring of them destroys the birds at a most critical moment."

It is a matter for deep regret that for various reasons the prosperity of many of our native birds, such as the chough, the raven, and many birds of prey, is at present markedly on the wane. Some, like the osprey and the marsh-harrier, are on the verge of extinction as indigenous species. Others, such as the kite, the sea-eagle, and the ruff, have been arrested on the brink by the introduction of efficient protection. Not a few birds that were once native are now rare visitors; examples are the bittern, the great bustard, the avocet, the black-tailed godwit, and the black tern.

On the other hand, some species are increasing; the mistle-thrush, the hawfinch, the starling, and the tufted duck are instances of species that have greatly spread and multiplied as British-breeding birds. Not only from a zoological but from an economical point of view, we cordially welcome what is being done in the way of judicious bird protection, not only by penal legislation, but positively by the establishment of "bird sanctuaries," and the like.

As Mr. C. William Beebe says: "Let us beware of needlessly destroying even one of the lives—so sublimely crowning the ages upon ages of evolving; and let us put forth all our efforts to save a threatened species from extinction; to give hearty aid to the last few individuals pitifully struggling to avoid absolute annihilation. The beauty and genius of a work of art may be reconceived, though its first material expression be destroyed; a vanished harmony may yet again inspire the composer, but when the last individual of a race of living beings breathes no more, another heaven and another earth must pass before such a one can be again."

Remarkable Changes now in Progress. Another evolutionary possibility is that the bird may make some big change in its habits; some constitutional change, arising mysteriously from within the germ, may lead to a change in the bird's manner of life. In the course of time this change of habit may come to be associated with a definite structural change which has been sifted out from among the continuous crop of "variations," because it was well adapted to the survival of the particular kind of bird in the new ways it has adopted.

Sometimes, on the other hand, some progressive structural change in a particular organ, such as the bill, may lead the bird to seek out some slightly different mode of life, or kind of food, or habitat—some new niche which it fits better. By big changes in habit and in structure, probably begun millions of years ago when bird structure was less fixed that it is now, there may have arisen strange types, like the penguins; and it is very interesting to inquire whether there are any hints of remarkable changes now in progress.

In illustration, we may refer to the well-known case of the kea parrot in New Zealand, which in the relatively short period since sheep-farming began in the colony has turned from its good old vegetarian ways to feeding on the fat above the kidneys of living sheep. This is a striking instance, but in not a few birds we find considerable plasticity as regards diet, and some of these may be hints of new departures whose significance will be plain to the ornithologist of the distant future. At the Antipodes there is a twilight-loving gull, whose food is said to consist exclusively of moths, and the herring-gulls in some parts of Britain are becoming vegetarians.

The Steamer Duck. A very remarkable and suggestive change seems to be in progress in the so-called steamer duck, found off the Falkland Islands. The young birds fly well, but as they become mature the power is lost. But the wings, too stiff to be of use in the air, are employed as paddles, and the steamer ducks move rapidly through the water, swimming quadrupedally.

In the spotted tinamou of South America the state of affairs is hardly less remarkable. The bird can fly, but it has so little mastery of its flight, either as regards direction or height, that its imperfectly co-ordinated flight is a danger.

We quote from Mr. Beebe another interesting case of peculiarity in flying power: "The wings of the owl-parrot of New Zealand are of full size, but the muscles are so encased in fat that they are useless for flight. These parrots feed on ground mosses, and being nocturnal, and therefore having few enemies, their only use for wings is occasionally to sail gently to earth, like a flying squirrel, from the trees in the hollows of which they sometimes roost."

In considering the evolution of birds, it is important to realise that it is still going on. Although there may not be in the future any very sensational new departure, the raw materials of evolution are still being ceaselessly supplied. In 1871 Mr. J. A. Allen measured numerous individual representatives of some common species of American birds, and found that as regards important points, such as length of bill and length of wing, birds of the same sex and season, caught at the same place, on the same day, showed numerous variations, often large in extent. It is in all probability by the patient study of these presently occurring changes, and of those which go on among domesticated birds, that naturalists will eventually be able to throw light on what remains so largely an unread riddle—the evolution of birds.

J. A. THOMSON

Power and Energy. The Wattmeter and the Integrating Wattmeter. Types of Meters. The Magnetic Brake and Starting Coil. How Tariffs are Fixed.

ELECTRICITY METERS

In discussing the subject of electricity supply meters, the reader must have a clear conception of the various units used, and he is therefore recommended to reread the article beginning on page 229, where questions of current, pressure, power, and energy were dealt with.

Power and Energy. As might be supposed, the consumer is charged according to the total amount of energy which he takes from the mains. The energy might, of course, be measured in foot-pounds, but, when we deal with energy in its electrical aspect, another unit, namely, the *kilowatt hour*, commonly called the Board of Trade Unit, is more handy. The *power*, at any instant, measured electrically in watts, is the product of the volts and the amperes at that instant. The *energy* is the product of the average power multiplied by the time during which the power has been taken. We can therefore differentiate the ideas of power and energy in one way by saying that the power may be continually *changing*—it may increase or it may diminish from instant to instant—whereas the total energy consumed is always *growing* from instant to instant, and the quickness with which it grows depends upon the magnitude of the power.

A power meter (in the electrical case called the *wattmeter*) gives its readings by means of a pointer which moves backwards and forwards over a scale [see page 232], and does not necessarily leave any permanent record, but an *energy meter* has a dial and a counting train, and at any time shows a totalised record of what has taken place during the whole time preceding the moment of inspection. Because of this an electrical energy meter is sometimes called an *integrating wattmeter.* There are therefore three quantities which have to be taken into account in the energy meter—namely, the current, the voltage, and the time; and every variation in any or all of them must be faithfully accounted for in the final reading.

Wattmeter and Integrating Wattmeter. The product of the current and voltage is measured by the wattmeter, and we shall now see how the wattmeter construction is extended in order to take into account the third factor. Fig. 209 shows a typical construction for a wattmeter, consisting of fixed thick wire coils which carry the current going to the lamps or the motors, and a thin wire coil which is connected across mains, and therefore carries a small current proportional to the volts. The coil is mounted in bearings, and is free to turn against a couple of controlling springs, which also serve to convey the current to the fine wire coil. Such fine wire coils, or the *voltage coils*, as we may call them, will thus be alive at the time that the meter is connected, but the thick wire or current coils will carry current only during the time that lamps are on or motors running.

It will be noticed that the coils have been placed at right angles to one another, so that, as explained on page 1417, there will be a drag on the coils, and the fine wire coil will turn round until the drag on it is counteracted by the force due to the winding up of the control springs. This drag will be proportional to the product of the currents in the two sets of coils [page 1417], and is therefore proportional to the power (watts) being absorbed in the circuit. Fig. 211 shows the development of this instrument into a supply meter. Here we have the current and voltage coils as before, the only difference being that the latter are spaced out around a cylinder, so that, as they revolve, there are always some of them in the active region near the centre of the current coils. Instead of the springs, a commutator has been substituted to bring the current into the rotating part, and the control now takes the form of fan blades, which are mounted upon the motor shaft. Again the thin voltage coils carry current all the time, the thick coils only when a load is on the circuit. The revolutions of the armature are counted up by means of a worm on the rotating spindle which engages in a tooth wheel which in turn is attached to a set of clockwork gears.

Control of the Revolving Element. In the wattmeter the moving part, when a drag came on the coil, wound up a spring to such an extent that the drag on the moving coils was exactly counteracted by the tension from the wound-up spring. The greater the drag on the coils, the more must the spring be wound up to counteract this drag, and therefore the greater the deflection of the pointer over the dial. In the supply meter we have this drag, but the control in this case has to be such that the resisting force depends upon the number of revolutions per minute, and not upon the amount of deflection from an initial position. As will be seen, fan blades have been mounted upon the lower end of the shaft for this purpose.

The resistance in the air to revolving blades is up to moderate speeds, proportional to the speed at which they are revolving, so that in this meter, if the current be doubled and the drag or torque on the revolving part be doubled, the speed will gradually rise to double its previous value, for then the air resistance in the fan blades will also have been doubled. In this way we see that the speed of revolution will be proportional to the load, and the indication on the dial will be a true record of the sums of the products of the current, voltage, and time during the various intervals that the electricity has been used.

The Magnetic Brake. The fan is not the most convenient form of brake to use, as at high speeds its braking force is not proportional to the speed, so that the forces at work in the meter have in consequence to be small; and, further, its action depends upon the extent to which it is surrounded by a casing which necessitates the meter being calibrated with the case on—a matter of inconvenience; and it is not readily adjusted when, during the testing, it is found necessary to make the motor run a little faster or slower. The form of brake more often used is shown in **210**, and depends for its action upon the generation of eddy-currents in a revolving metal disc by means of a permanent magnet. This magnet is capable of easy adjustment, so that, by making the magnet cover more or less of the disc, the meter is made to revolve slower or faster.

Details of the Meter. The type of meter which we have taken for illustration is that brought out by Professor Elihu Thomson, in America [**217**]. The revolving part or armature consists of eight coils equally spaced around the periphery, and connected to a small eight-part silver commutator. The current which passes through the armature is wasted so far as the doing of useful work is concerned, and should therefore be as small as possible. For this reason each coil on the armature has as many as 800 turns, and, taken altogether, the total resistance across the brushes is 640 ohms. Sometimes this is not considered sufficient, and more resistance is inserted in the armature circuit in the shape of coils stowed away at the back of the meter case. This part of the circuit is therefore a high-resistance shunt.

The brushes are of springy steel, but actual contact on the commutator is made by small silver plates soldered on the ends. As regards the mounting of the meter, the shaft terminates in a polished steel point which rests on a jewel bearing. To preserve the point and jewel from damage due to jolting, the bearing is supported in guides by means of a spiral spring, so that a little up-and-down motion is obtained.

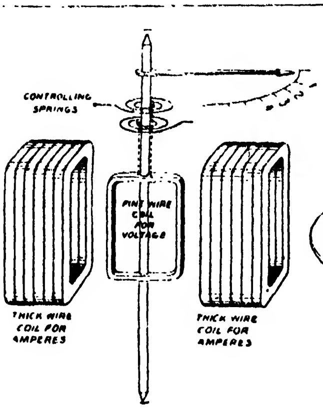
The Starting Coil. In the meter, as so far described, a portion of the torque given by virtue of the current in the main coil has to be used to overcome the friction of the meter. The meter will consequently read slow by a percentage which increases as the load goes off, and it may even happen that the torque produced by the current taken to light one lamp may not exceed the frictional resistance of the meter, and so no turning will take place, and the consumer might continue to use the current for the single lamp without having to pay for it. In order to overcome the frictional resistance by a torque which is not derived from the main current, coils of fine wire are inserted inside the main coils, and are connected in series with the armature, their position being adjusted so that there is always a small torque being exerted which will counteract the frictional resistance.

Types of Electricity Meters. Innumerable forms of electricity meters have been tried, and some are in successful use in special cases, but present-day practice has largely settled down to two types, the motor meter for continuous currents, and the induction meter for alternating currents. Clock meters, integrating meters, and electrolytic meters have at times been in favour, but experience has not extended their use.

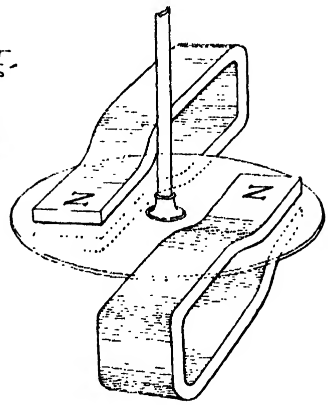
The best-known clock-type meter is the Aron, where the variation in the time of vibration of two similar pendulums is a measure of the current which has passed. This is an accurate and reliable meter, but is much dearer than others.

The integrating meter, in which periodical readings were taken and recorded, has also fallen into disuse; while the electrolytic meter, in which the amount of electric energy which has passed is measured by the amount of chemical change it has effected, is now largely confined to the measurement of very small currents.

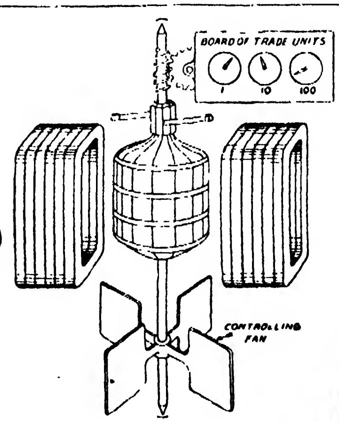
Motor Meters. When the actual energy which has passed in a continuous current circuit is to be measured, a meter of the Thomson type is used. Usually, meters are used to measure the energy sold from public supply mains to private consumers. It is supposed that the



209. A WATTMETER



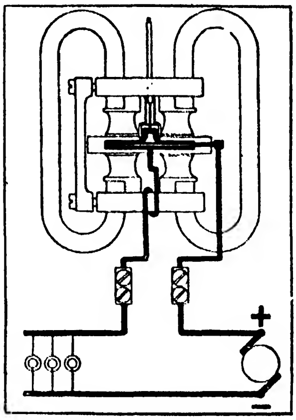
210. MAGNETIC BRAKE FOR METER



211. DIAGRAMMATIC ENERGY METER

voltage is kept constant—or at any rate within 4 per cent. of the declared voltage—so that the current which passes is a fair, though not entirely accurate, measure of the sold energy.

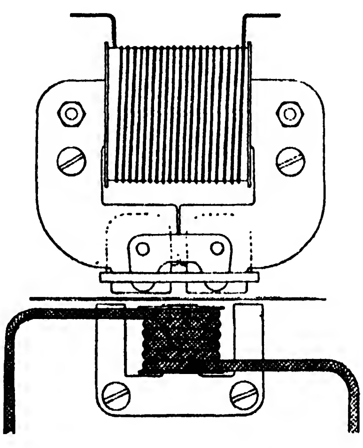
It is possible, therefore, to measure current by means of a motor meter like the Thomson, but using permanent magnets in place of the electromagnet; and a number of commercial meters act on this principle, a very small proportional part of the whole current being taken through the revolving armature.



212. MERCURY BATH METER

The best-known motor current meters for continuous currents are those of Ferranti and of Chamberlain and Hookham. In both of these a metal disc rotates in a bath of mercury, and Figs. **212** and **215**, which illustrate the action of a Ferranti meter, will suffice for both. The Chamberlain and Hookham meter has a single in place of the double magnet of the Ferranti. There are either one or two curved permanent magnets, which have pole pieces forming the top and bottom of a space filled with mercury. A metal disc rotates in this mercury, and to the spindle of this disc the counting and registering movement is fitted. The current is led, as shown, to the side of the mercury bath, and flows across the metal armature disc to the centre, whence it is led to the outgoing terminal.

Whenever current, in passing through the meter, crosses the armature disc, it sets it rotating, the speed tending to increase very rapidly. The rotation of this solid metal disc in the strong magnetic field produced by the permanent magnets sets up in the disc eddy-currents, which tend to stop the rotation of the disc. The final result is that increases of speed attained by this disc correspond to increases in the rate of flow of the current; and that counting and integrating the number of revolutions of the disc gives accurate measurements of the total current. Rather it would do this if it were not for the friction losses in the meter itself. These are very small, and are compensated for by passing a coil of the outgoing wire round an electromagnet, which to a very small extent operates counter to the power of the permanent magnets.



213. MOTOR OF FERRANTI METER

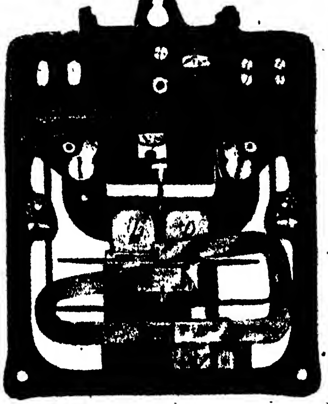
Alternating Meters. For alternating current work it is necessary, on account of the inductive character of many loads, to measure energy, not current. For instance, if a current meter were used to measure an arc lamp circuit, the amount indicated on the meter would be far more than the energy actually used.

There are, however, a number of types of induction watt-hour meters which are both cheap and accurate. Figs. **214** and **216** illustrate the latest type of the Ferranti meter, and **218** shows the Westinghouse Company's "N" meter. Their action is illustrated in **213**. The pressure coil, or shunt coil, is shown at the top of the meter; the current coil, of thick wire, passes through the bottom part of the meter. The poles of the two electromagnets nearly touch, but in the intervening space a very light metal disc which actuates the counting mechanism is free to rotate. There is also a permanent magnet so placed that the disc is made to rotate at one part of its movement between its poles.

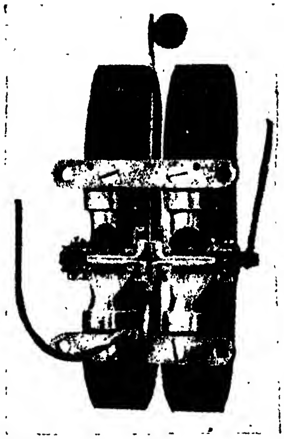
When current passes through the meter, the eddy-currents, which are induced in the rotating disc by the shunt field, react on the series field and produce a driving torque. Owing to the reactions of the series and shunt fields the resultant torque is proportional not to the current alone but to the energy. The rotation of the light disc is controlled, as in the continuous current mercury meter, by the permanent magnet field, with the result that the number of revolutions made by the disc is a measure of the total energy. To ensure accuracy, the aim of all motor makers is to produce as large a driving torque as possible and, at the same time, to reduce the weight of the revolving part to the lowest point.

Accuracy of Meters. As the success of electricity supply undertakings depends to a large extent upon the accuracy of the meters, the greatest care has been taken to make meters which start with very small currents and are accurate under all conditions. Practically all modern meters are accurate to within 2 per cent., from $\frac{1}{20}$th load up to $1\frac{1}{4}$ times full load; and many kinds of meter, after prolonged tests by the Board of Trade, have been approved as suitable for general use.

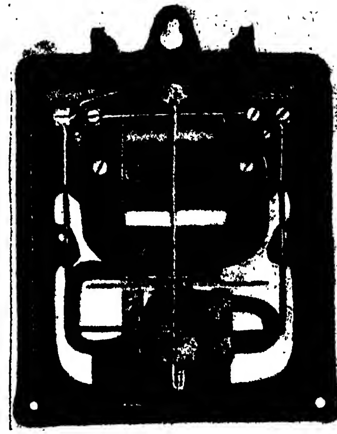
Meters and Tariffs. Much might be said upon the question of meters and tariffs. It will easily be seen that the charge made to any consumer should really be divided into two parts, one part depending on the amount of current taken at any one time, and the other dependent on the length of time during which he has taken that current. For instance, if a consumer's load is 5 KW, the central station must always be ready to supply that 5 KW, whether the consumer wants it for six hours a day or only fifteen minutes. This part of the charge made to the



214. FRONT VIEW OF FERRANTI INDUCTION METER



215. MERCURY BATH SHOWN IN SECTION

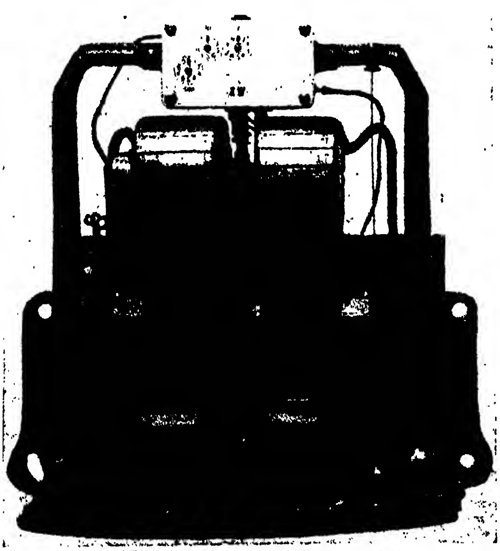


216. BACK VIEW OF FERRANTI INDUCTION METER

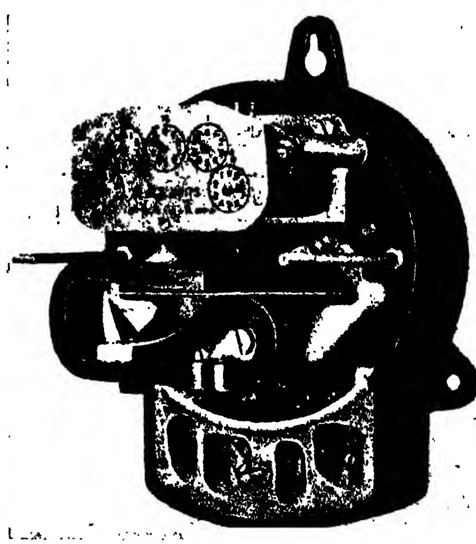
consumer is constant, and independent of the load; and many stations assess its value at £4 10s. per KW per year. That means that this customer must pay the central station £4 10s. × 5 = £22 10s. per year, or £5 12s. 6d. per quarter, in order to recoup them for always being prepared to give him 5 KW of energy. The actual cost of supplying the energy is in many stations less than ½d. per unit, and consequently it is found profitable to charge £4 10s. per KW demand per annum, plus ½d. for each unit supplied.

Many automatic appliances have been devised to register the maximum amount of energy taken by a customer; some of them are combined with meters. This plan of dividing the charge made to consumers into "standing" and "running" costs is the only one which is really fair to supplier and consumer, but it is not an easy one to explain. Consequently, some supply authorities prefer to make a flat charge per unit, trusting to the peculiarity of one person's demand averaging out that of another's. Other engineers use "two-rate" meters, which measure all energy supplied during certain hours correctly, and all supplied during other hours at half rate, thus differentiating the price according to the time at which it is supplied.

The whole problem of successful electricity supply depends upon means being found to use the energy capable of being produced by a central station, not for one or two hours a day, but for eighteen or twenty. It costs as much, practically, to equip a station which works at full load one hour a day as one that works at full load for eighteen to twenty hours, but the revenue obtained from the units sold is very much higher in the second case than the first, though the extra cost of running the station is only a little more than the cost of the extra fuel and materials. SILVANUS P. THOMPSON.



217. ELIHU THOMSON METER



218. THE WESTINGHOUSE "N" METER

Parts of the Instrument. The Bow. Tuning. Expression. First, Second, and Third Positions. Exercises.

THE VIOLA

The viola, called sometimes the tenor, is a member of the violin family, to which instrument, although larger, it bears a very close resemblance. So great, indeed, is this similarity that we not infrequently find a viola player who began his musical career as a violinist; and the study of the violin will be found beneficial when we take up the larger instrument. The aspiring viola player is therefore recommended to study the course on the VIOLIN [see page 1954].

The size of the viola is determined by no hard and fast rule, but it is, roughly speaking, about 3 in. longer than the violin, its other measurements being proportionately larger. Yet this increase of size is acoustically insufficient for the viola's deeper compass (a fifth below the violin), but if it were made of the full size demanded by its pitch it would be impossible to hold it in the usual way. It is generally considered that this relatively small size is accountable for the viola's peculiar quality of tone, and there is no doubt that the larger the instrument, the fuller and more resonant is its sound. As may be supposed, the tone of the viola bears a certain resemblance to that of the violin, but it has a distinguishing quality of its own—in the higher positions a nasal and penetrating *timbre*, while the middle and lower registers are apt to sound weak in any save skilful hands.

The names applied to the various parts of the instrument will be understood on reference to 1.

The *body* consists of the *belly*—*i.e.*, the front—of the instrument, the *ribs* (forming the sides), and the *back*.

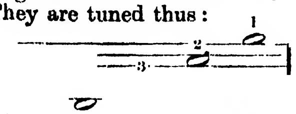
a is the *neck*, terminating in the peg-box.

b is the *scroll*, at the end, merely ornamental; attached to the neck is the fingerboard, *c*.

d is the *tailpiece*, to which the ends of the strings are attached, afterwards passing over the *bridge*, *e*.

1. THE INSTRUMENT

The *f* holes, or sound holes, are marked *f*. The four strings are made of gut, the two lower ones being covered with fine silver or copper wire. They are tuned thus:



It should here be mentioned that music for the viola is written, for the most part, in the alto clef. [See MUSICAL THEORY.]

These four notes sounded by the strings are termed *open notes*. The other sounds necessary for the completion of the scale are obtained by firmly pressing the string on to the fingerboard with the fingers of the left hand, thus in effect temporarily shortening the string, the exact pitch being determined by the position of the finger on the fingerboard. Thus, on the C string, by pressing the first finger on the string about 1½ in. from the end, the note D will be produced. Placing the second finger the same distance further on will give E. F, being a semitone, will lie closer to the E, while G with the fourth finger is again a whole tone. This G is identical in pitch with the open note of the third string. It will now be seen that by the successive use of three fingers on each string a complete scale of C for two octaves and a third can be produced without shifting the hand. The notes thus formed comprise the first position.

The manner of holding the viola is so similar to that of holding the violin that the student is referred to the instructions given for that instrument [see page 1956]. The only difference is that, on account of its larger size, the arm of the player is less bent than when holding a violin. The bow, too, is held and manipulated in a precisely similar manner.

The Strings. Before beginning to play, the student should devote a little time to learning to put on a string and then to tuning the viola. The strings when bought usually contain sufficient for two lengths, with the exception of the covered strings, which are made to the size required. Strings will be found to vary somewhat in thickness; the exact gauge best suited to any instrument is a matter that can only be decided by experience. Having obtained a suitable string, proceed to make a knot at one end of it. Pass this through its proper hole in the tailpiece, and push the string in to the adjoining slot, which is too narrow to allow the knot to be pulled through. One end being thus firmly held, pass the string over its notch in the bridge and along the fingerboard to the peg. In the illustration, the four pegs, marked 1, 2, 3, 4, correspond respectively to the first,

second, third, and fourth strings, and on no account must a peg be used for any but its correct string.

The end of the string is now to be threaded through the hole in its peg, and the latter turned in such a direction that the string shall pass *over* the peg—not under. After half a turn, the end can be extracted from the box and held so that the string shall pass over it on each subsequent turn of the peg, thus holding it firmly, and preventing it from slipping. The string should be made to coil upon the peg in a direction tending towards the larger end. If the peg shows any tendency to slip in its socket, it should be pushed inward as it is turned; being made to taper at one end, this will have the effect of wedging it into its hole.

Tuning. The strings are tuned by increasing or decreasing their tension by means of the pegs. The more tightly the string is strained, the higher, of course, is the pitch.

The A string is always tuned from some other instrument whose pitch does not vary. This is, of course, in unison with the second string of the violin, and is the note (arbitrarily) from which almost all instruments are tuned. From this fixed point, as it were, the other strings may be easily corrected, it being borne in mind that each is a perfect fifth from its neighbour, and that a perfect fifth is the most sensitive of all intervals; the slightest inaccuracy of one of its constituents produces a harshness that may be recognised by the most inexperienced ear. While the tuning is in progress the strings should be sounded with the bow; therefore it is well to be able to manipulate the peg with one hand, while the other holds the bow. The usual method of managing this may be learned by watching any violinist tuning his instrument prior to playing.

The viola must be firmly held by the chin. To assist this, a pad may be placed under the left lapel of the coat, beneath the instrument. The chin-rest also affords help in this matter, while the neck of the viola is to be supported in the crook of the thumb and first finger. This support should be sufficient to keep the instrument quite steady. Any attempt to grip the neck with the fingers, even between the forefinger and thumb, is inadmissible, and would, indeed, be fatal when we come to shifting to the higher positions.

The Bow. Now let us turn our attention to the bow. The different parts of this are shown in 2. The length should be about 29 in.

a is the stick, which is usually made of lance-wood or snake-wood.

b is the hair, which is fastened to the head (*c*).

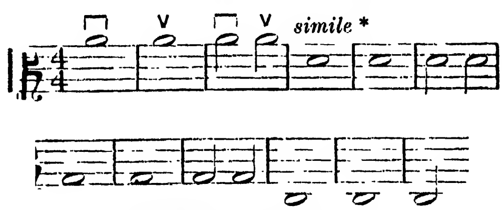
d

2. THE BOW

By means of a nut (*d*), which screws into the head, the hair can be made tighter or looser. When not in use the bow is kept loosened, and before beginning to play, it must be tightened by turning the nut. It must not be made so tight as to lose its elasticity, but tight enough to prevent the stick from coming into contact with the hair when playing *fortissimo*. On each occasion, before using, the bow should be rubbed over a piece of resin, care being taken that the ends as well as the middle of the hair receive their share.

The bow is held precisely in the same way as the violin bow, but one or two points may be reiterated. It should not be gripped too tightly, but held easily between the first, second, and third fingers opposed to the thumb; the little finger is used to balance the bow. Any additional pressure of the bow on the strings is produced by the middle joint of the forefinger. The hair of the bow must not be placed flat on the strings, but the bow must be turned so that the edge of the hair furthest from the player first comes in contact with the string. It is important when playing on the first string to remember to keep the elbow in, close to the side of the body; one of the commonest faults with beginners is to raise the elbow until the upper-arm is almost in a line with the shoulder. Apart from the awkward and ungainly appearance caused by this attitude, it is almost impossible to control the bow with due delicacy from this strained position.

Now try to play the following exercise very slowly and with an even tone. The sign ⊓ signifies a down-bow—*i.e.*, starting at the nut and drawing to the point; V is used to indicate an up-bow, from the point to the nut.



[* *Simile* -*i.e.*, in the same manner.]

Hold the viola and bow as directed, and bring the latter, at the end near the nut, on the A string, at a place approximately midway between the bridge and the fingerboard. The wrist should, at this point, be somewhat bent; the wrist-bone, that is to say, should be higher than the hand. Now draw the bow slowly across the string, endeavouring to keep the pressure on it perfectly even throughout the stroke. See, too, that the bow remains on the same part of the string throughout, and does not get either nearer to the bridge or to the fingerboard. Take care that the bow remains at right angles to the string all the time, and if, on nearing the point, it is seen to be otherwise, the fault will probably lie with the arm, which may have been moved from the shoulder joint instead of the elbow, thus swinging round the whole arm and causing the elbow to move behind the body.

This is a bad fault, and must be carefully guarded against. As a matter of fact, after half the length of the bow has been drawn, the upper-arm has very little to do, the greater part of the movement being caused by the unbending of the elbow. The wrist, also,

gradually unbends until, at about two-thirds of the bow, it is level, and during the remainder of the stroke it bends in the reverse direction—that is, with the wrist-bone lower than the knuckles. This movement will be found to occur naturally if the bow is kept straight and the arm near to the side.

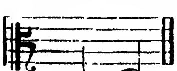
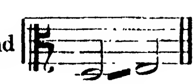
For the up-bow the movements are simply reversed.

The bowing for the other three strings is very similar. The chief point of difference lies in the elevation of the upper-arm, which is to be raised sufficiently to allow the bow to lie comfortably on the string.

Expression. So far nothing has been said about the sounds we are producing from our instrument. The intensity of the sound —*i.e.*, its loudness or softness—is governed, to some extent, by the speed of the bow, but principally by the degree of pressure exerted by the bow on the string (by means of the forefinger). When playing *pianissimo* the weight of the bow on the string is controlled by the little finger, which acts as a counterbalance. A difficulty to the beginner is always to start so that an unpleasant scraping shall not intrude itself; this seems to be caused by a combination of too much pressure on the bow and too slow a speed, but principally the former, and may be overcome by judicious attention to these two points. The exercise should then be practised with a *crescendo* and *decrescendo* on each note, beginning and ending quite softly and swelling to a *forte* in the middle.

As soon as a moderate amount of mastery over the bow arm has been attained, we may turn our attention to producing notes other than the open sounds. Before beginning this, however, it is necessary to insist that the student shall listen attentively to every note he plays; for we have nothing but the ear to tell us whether or no we are playing in tune. The position of every note must be found out and learned accurately; there must be no shuffling and sliding of the fingers to correct a faulty intonation. Therefore, let it be emphatically reiterated, **listen,** from the very beginning until the habit has been acquired of stopping notes dead in tune, and after that still listen, to ensure correct playing.

Now, it is easy to say that on an average viola the distance from

 is 1½ in., and 

about ⅛ in. less, and so on. This may be quite true, but even the very beginner cannot put down his bow and measure off the distances upon the fingerboard. He must use his ear to tell when the note is sounding in tune, and then remember the positions of the fingers that gave the correct sound. If the student has small hands he may find G with the fourth finger rather an awkward stretch, but that is no reason for permitting the note to be played flat, or for substituting the open note. Let the little finger have the exercise it stands in need of, and in a very short time it will cease to give trouble.

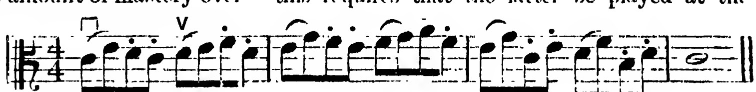
Space forbids the inclusion of exercises, but the student should, at this point, procure a book of elementary studies for the viola. Those by Hofmann may be recommended, or the "Viola School," by Hans Sitt, will be found useful. Both are published in the Peters Edition.

It is not necessary that a whole bow be used for each note as we have hitherto done. Several notes may be stopped, even those lying on adjacent strings, during the time the bow is travelling from one end to the other. A slur, thus:

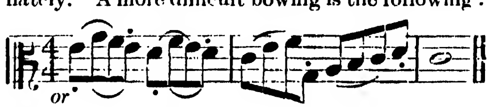
is used to indicate that all the notes under it are to be played in one bow. The smooth effect of this is termed *legato*, the word *staccato* being employed to indicate short notes played each with a separate bow; the latter are sometimes marked with a dot, thus:

A variety of patterns, formed of a combination of legato and staccato, is thus possible. Many of these require careful management of the bow to render them successfully.

In this example, more bow is required for the slurred notes than for the detached ones, and this requires that the latter be played at the opposite end of the bow for each group alternately.



A more difficult bowing is the following:



It would seem that three times as much bow is wanted for the *legato* notes as for the one *staccato*, but if this is done a very short time will bring us to the end of the bow, and make it impossible to continue without an ugly break in the music. The only way to overcome this difficulty is to take an equal amount of bow for the two unequal sections of the group—that is, a rather slow down-bow for the three slurred notes and a quick up-bow for the last note, taking the bow back to the starting-point. The use of the following sign

is to be interpreted thus: the slur indicates one bow for the six notes; the dots indicate that the notes are to be separated—that is, the bow must stop between each note. This is sometimes called *portamento.*

When we reach the use of sharps and flats our difficulties materially increase, for each finger has now three different positions to remember. Thus, on the fourth string, the first finger will, besides the D♮, play D♭ (C♯), half a tone below its normal position, and also D♯, half a tone above, despite the fact that this latter is the same sound as the E♭, which is taken with the second finger. The position of the hand should not be altered at all, merely the finger advanced or put back to a position midway between two consecutive tones. The other fingers have a corresponding series of extensions and retractions for stopping the notes a chromatic semitone on either side of their normal position.

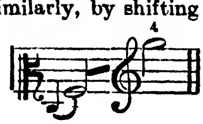
It will be seen that by inclining the bow so as to touch two strings simultaneously, double notes may be played; the chief difficulty with these will be found in keeping the tone evenly balanced on both strings. Three, and even four, notes may be played almost together, by drawing the bow rapidly across the strings, although only the highest two are actually sustained.

Thus:  which sounds 

never the reverse . It is more difficult when none of the notes are open ones, thus:  The intonation must be very carefully attended to.

Still harder is this position:  But such chords are not very common.

Positions. The student will do well to confine himself for some time to the first position only, until he has acquired a very considerable mastery over exercises and easy pieces within his abilities.

If we shift the hand along the neck of the viola, so that the first finger is in a position to stop the notes formerly played by the second, and, in consequence, all the other fingers are also playing a note higher than previously, the compass will extend to F on the first string instead of E, and we shall be playing in the second position. Of course, the lowest note, D, on the fourth string is now inaccessible; we have merely transposed the compass a tone higher—not extended it. Similarly, by shifting the hand still a note higher, the compass will extend: 

This is the third position. In a like manner, the fourth, fifth, sixth, and seventh positions are attained, each situated a note above the previous ones.

There are several things to be learned afresh for each new shift. First, the position of the hand along the neck of the instrument must be remembered, so as to bring the fingers over their correct note positions. Secondly, an entirely fresh fingering has to be memorised and connected with its corresponding position; and here much confusion will result if we try to proceed to fresh difficulties before thoroughly mastering the earlier ones. Thirdly, as we advance to the higher positions the notes become closer together; they are no longer at the distances they occupied from one another at first; in the very high positions the fingers become uncomfortably close together, and there is consequently even less latitude for error than before. It is important that one position be thoroughly learned before studying another.

It is very usual, and the practice has much to recommend it, to learn the third position before the second. It is a more generally useful one, and has, furthermore, this advantage: just as, in the first position, the hand was at the end of the neck—the projection of the peg-box forming a guidance for the thumb—so now, in the third position, the hand is brought to the other end of the neck, and allowed to rest against the shoulder of the viola body. This establishes a fixed point of aim for the hand, which is not possible in any of the other positions, although in the fifth and higher the thumb should always cling to the viola in the angle of the neck. When the fingering of the third position has become tolerably familiar, exercises should be practised wherein it is combined with the first position. In changing from one to the other, the hand and finger—it is, perhaps, easiest with the first finger stopping its note—should be swiftly slid together, with no independent movement of either.

Mention should be made here of what is known as the half position. It is situated a semitone below the first position, and its use will best be seen from an example.

By playing this with the fingering shown, the passage becomes considerably easier than if played in the first position. From what has been written, the student should have no difficulty in learning the remaining positions, with the aid of a suitable book of studies properly graduated as to difficulty.

For an explanation of harmonics and much other matter, the student is referred to the instructions on the violin.

PAUL CORDER

Hackling Flax. Wet and Dry Spinning. Yarn Bleaching. The Treatment of Jute and Hemp. Moisture and Strength.

FLAX, JUTE, AND HEMP SPINNING

We have seen that the bast fibres are all long ones, and it has become apparent from the chapters on the spinning of cotton, wool, and silk that the manufacturing treatment suitable for any fibre is largely determined by the factor of length. The methods employed in spinning flax, hemp, and jute are like to each other, and they bear marked resemblances to processes that have already been described in connection with other materials. There are incidental differences in methods and in the names given to the same method, but none of these is very difficult to understand.

Hackling Flax. Flax manufacture begins upon the *stricks*, or handfuls of fibre delivered from the *scutching mill* [page 1018], and the first operation is that of *hackling*. The object is to straighten and divide the fibre, and to remove the short material, or tow. Flax is given a *roughing*, or rough hackling, by hand as a preliminary treatment. Seizing it by the top, the rougher takes a strick out of the bundle, and, after winding it round his hand, dashes the flax with force into the teeth of a hackle, or comb. The operation is repeated as often as need be, and, if necessary, other and finer combs are used successively to obtain the desired result. Hackling can be completed entirely by hand, but after a first roughing the usual course is to pass the flax through the cutter and into the hackling machine.

All parts of one stem of flax are not of equal value. The root end is coarse and the tops are unequal. The middle is the choice part, and *middles* of 14 to 18 inch lengths are obtained. When the middle is used in one length the flax is spoken of as *long line*, but the middles may be cut into two, in which case they form *cut line*. The cutting is done by a machine, into which the flax is fed in handfuls between grooved and weighted nipping rollers. While firmly held between these rollers, the material is cut by a blade, leaving the tops in one hand of the machine boy and the root ends in the other hand.

The Machine Hackle. The machine hackle has provision for holding or clamping the fibre, for moving these holders along in succession, and meantime for allowing teeth to comb the flax. The material is spread evenly upon an iron plate, and upon the top of this another plate is screwed, the fibre projecting as a fringe. The holders are placed edge downwards in the overhead channel of the machine so that the flax hangs down. Beneath the channel are the *hackle-sheets*, which are endless leather belts working vertically over rollers, and these sheets carry bars of wood studded with steel pins of about one inch in length. The sheets are set closely in face of each other so that the teeth more or less intersect, and the machines are made with from eight up to twenty *tools* or sheets, according to the class of flax they are to work. The teeth on the first tool are comparatively thick and wide apart, and on the successive sheets the pins are finer and closer together.

When the machine is in motion the *head*, or channel, rises and falls gently, and gradually makes a wider sweep until the whole of the pendent fibre has been presented to the hackles. When the holder has been combed through it receives a *shift*, and is moved on to the next tool. The progress is continual, and with every shift one holder is liberated and another holder is put in. One passage through the machine dresses half the flax, being that half which projects, and the holders are returned to the starting-point so that the fringe can be reversed. The root ends, which are always the first to be hackled, are clamped in the holders, and the tops, which have hitherto been nipped between the plates, are exposed.

The hackle teeth comb out and carry downward the *tow*, which is removed from the pins by circular brushes and stripped by a doffer-roller and a knife. The tow is removed and treated by carding engines as a short fibre, and the dressed flax, or line, is dealt with in a manner closely corresponding to that used in spinning worsted and silk waste. The line is first passed to the sorter to be classified into qualities, and to have its inferior portions removed and its fibres straightened. Hand hackles with teeth much finer than those of the rougher are used by the sorter, and from him the line passes in turn to the spreading machine.

Spreading and Gilling. The spreading machine, or *spread board*, made for flax has the same function as that used on waste silk—the conversion of a fringe of fibre into a continuous sliver. It has from four to eight travelling aprons, upon which pieces of dressed line, similar in size, are laid. As these travel forward other pieces are laid above them so that the ends overlap. The material travels between feed rollers when it is penetrated by the teeth of gills [page 2349] which travel faster than the feeding rollers, and bear the flax forward at the same time that they make parallel and divide the fibres. The slivers pass through the machine independently of each other, and are drawn off by delivering rollers separately, but in leaving the machine all the slivers are brought together, formed into one, and coiled mechanically in a tall can. The gills are propelled by worm gear, and it is worth noting that it was a flax-spinner, William King Westley, of Leeds, who invented, in 1833, the *screw gill*, which has become indispensable in the preparation of all fine, long fibres for the spinning machine.

Spreading machines are usually fitted with a bell that is automatically rung when a standard length of 500 or 1000 yards of sliver has been delivered, and by weighing this length and adjusting the feeds the fineness of the resultant yarns can be controlled. In using the ordinary spreader, one girl is needed at the feeding-apron for each sliver, but to do away with most of this labour a system of *heavy spreading* has been brought into use. Under this system the flax goes through in one coarse sliver instead of in from four to eight finer ones, and is reduced to its proper fineness by subsequent extra treatment by the drawing frames.

There are three or four drawing frames in a set of flax machinery, and they are used to amalgamate and to draft slivers produced by the preceding

machines. The drawing frames receive at each of their gill-heads from four up to twelve slivers, and deliver finer sliver coiled into cans. The next step is to bring the sliver to a roving frame, on which it is drawn finer by roller action and spun into roving by the action of a bobbin and flyer, fitted with a differential motion to ensure regular speed.

Tow Spinning. The cheaper, shorter, and more imperfect fibre from which tow yarn is made has more than one origin. We have seen that *codilla tow* is made in scutching flax straw, and that hand hackling and machine hackling both bring away tow from the long line; these materials are of different qualities and require treatment of varying degrees of severity. Coarse, strong tows are put through a *breaker card*, or *devil*, a machine with a 72-inch cylinder set with inclined spikes rather less than one inch long. The cylinder carries upon its periphery worker, stripper, and doffer rollers covered with stout card-clothing which open and straighten the fibres and dislodge woody and other impurities. The tow is formed into a film, or lap, which is condensed into a sliver and led to a *finisher* card. These cards are made with varying numbers of worker rollers, and are covered with teeth of greater or less fineness in accordance with the class of work for which they are intended.

The carded tow is passed through drawing frames like those that are used for line, but with their feed and delivery rollers nearer together. Tows for making fine yarn are frequently combed, in which case sliver from the first of the drawing boxes is led into a machine working upon the Heilmann principle [page 1693] and delivering sliver from which all fibres below a definite length have been removed.

Wet Spinning and Dry Spinning. The finest and smoothest linen yarns are made by the process of *wet spinning*. The machine employed is upon the flyer principle, with brass-faced and fluted drawing rollers. A trough holding hot water runs the whole length of the frame, and through this the roving passes before entering the drawing rollers. Fibres of flax [page 1295] are not simple structures, but are built up of ultimate filaments or cells bound together with a natural resin or gum. This *pectose* is softened by the hot water, and the drawing rollers, which are heavily weighted and set close together for the purpose, draw the individual fibres finer by drafting the filaments which compose the line.

Flax cannot be spun to as high numbers by *dry spinning*, nor is dry-spun yarn as smooth as wet-spun, but it is very strong when long line is used, and tow yarns when dry-spun are more bulky than those that have been spun wet. Whereas there is a very short *ratch*, or separation, given to the drawing rollers in wet spinning, a long one, equal to the length of the longest fibre, is given when the yarn is spun dry. A compromise between wet and dry spinning is sometimes effected by adding a cold-water damping roller to a dry-spinning frame, so that just before the yarn is twisted by the action of the bobbin and flyer it receives a slight moistening. The result is to reduce the stiffness of the dry fibre and to assist the making of a smooth yarn.

Wet-spun yarns, which form the main part of those spun in the United Kingdom, are reeled from the spinning bobbins into hanks, and these hanks are hung over poles and left to dry. When dry, the hanks are twisted freely to take away their stiffness, and are bunched together into bundles. Line yarns are numbered according to their *leas*, or *cuts* (of 300 yards), and 20-lea means $20 \times 300 = 6000$ yards per lb. Tow yarns are numbered in pounds per *spindle* (of 48 leas), and 8-lb. tow yarn means that 48 leas ($48 \times 300 = 14{,}400$ yards) weigh 8 lb.; or, in other words, that the yarn runs 6 leas ($6 \times 300 = 1800$ yards) to one pound.

Yarn Bleaching. The resins present in flax are removed more or less completely in bleaching, an operation that is sometimes carried out upon hanks of yarn, but is more often deferred until after weaving. The yarn is boiled for three or four hours in a weak solution of soda ash in enclosed vessels called *kiers*, fitted with a perforated false floor. The kier is heated by steam and is fitted with a central pipe, up which boiling water from the lower compartment is blown by the incoming steam, and is thus distributed over the hanks. The yarn is afterwards washed with plain water and squeezed semi-dry, and is placed next in a tank containing a solution of bleaching powder, where the hanks are looped over rollers, and are kept rotating. After an hour the yarn is washed and lifted into another tank containing a weak solution of mineral acid. After being washed here the hanks are returned to the kier. This round of operations is repeated as often as is necessary to secure the requisite degree of whiteness and purity. The best finish is obtained by leaving the hanks to lie for some days on the grass to be bleached further by the sun and air.

Jute Preparation. The routine of the flax trade is followed in spinning hemp and jute, with only such modifications as are necessitated by the greater coarseness of the fibres and by the purposes in view. Jute arrives at the mills in tightly pressed bales, and the stricks, or *heads*, into which the contents are divided are hard and unpliable. The jute is passed into an *opening* machine, which opens the heads by crushing them. The machine has three pairs of large rollers, with coarse flutings or small round knobs upon their surfaces, and springs or weights above their axles to increase their crushing power. The opened jute is delivered to the *batchers*, who divide the large stricks into smaller portions in readiness for the softening machine.

The Jute Softener. The jute softener has some 63 pairs of small fluted rollers pressed together by spiral springs, and the jute in passing through forces up the upper rollers. Advantage is taken of this raising of the rollers to regulate automatically the overhead *batching gear*, by which water and oil are delivered to the material from tanks in measured quantity. Four to eight gallons of water and one to two gallons of oil are applied to each 400-lb. bale, and the mineral, or mineral and whale, oils used lend an odour that can often be detected upon such fabrics as *hessian*, or packing canvas. The oiled stricks are placed upon barrows and left overnight, to allow the mixture to penetrate the mass equally.

Jute is long enough in staple to be hackled like flax, but from motives of economy it is most often treated like tow upon a breaker card and next upon a finisher card. Two types of carding machines are in use, known respectively as *up-striker* and *down-striker*. The former has its worker and stripper rollers above the cylinder, while in the latter case these rollers are placed beneath. The jute is fed to the apron of the breaker card in weighed quantities calculated to produce a rove or sliver of the weight desired, and this quantity is what jute spinners call the *dollop*.

Drawing and Spinning Jute. The carded jute is passed on to drawing frames of less fine construction than those used for flax and fine fibres at large. Screw gills, in which the fallers are regularly advanced by the motion of a worm, are used

in the second drawing of common jute and in the first and second drawing of the finer yarns. Gills on the *push bar* principle, in which the fallers are thrust along by the raising of a new faller from the bottom slide, *open link* gills in which the toothed bars are secured together by a chain, and *rotary* gills are used to some extent for the sake of cheapness. Jute, being usually spun into coarse yarns, does not receive or require the large number of *doublings* during drawing that are given to the more expensive fibres. From three to five slivers are run into one at the first drawing frame, and from five to seven slivers at the second, and the sliver is twisted into roving upon a coarse frame similar to that used for flax. The spinning is done on flyer frames, like those employed in the dry spinning of flax.

The out-turn in jute spinning is heavy, for the reasons that the yarn is relatively thick and little twisted, and that the machines can be run faster than upon fine materials. Common jute yarn runs from 7 to 10 lb. per spindle of 14,400 yards, equalling 2057 to 1440 yards per lb.

Treatment of Hemp. Both flax and jute are used in making cordage in addition to fabrics, but cordage is the principal article made from true hemp and from the various bast and leaf fibres [page 1019] commercially called hemps. The fibres are so long and strong that it is generally necessary to use a machine expressly for the purpose of breaking them. Handfuls of long hemp are wrapped once or twice around the ends of two square projecting arms, one of which is stationary and the other made to revolve at will. When the machine is thrown into gear tension is set up, and the hemp is snapped into two portions.

Hemp intended for spinning and weaving is crushed and softened in such machines as are in use for jute, or is rolled under the fluted rollers of a heavy circular machine. Hackling is done on machine hackles similar to those used for flax, and drawing is performed upon push-bar gills like those used for jute. The sliver is roved upon the roving frame, and the roving is spun in the same way as dry flax. Hemp tow is treated on carding machinery like flax tow, and spun either wet or dry.

Hemp Cordage. Hemp for cordage may be hackled by hand and hand-spun in the ropewalk from a bunch of fibre carried by the workman. The harder hemps need to be *scutched* by the teeth of a revolving drum. When the fibre has been opened well, and has had its hard ends removed, the stricks are placed in a combined machine which first hackles and then gills the fibres, turning out a continuous sliver. Slivers from this machine may be passed through second and third machines of increasing fineness of teeth. It is unnecessary to rove the sliver in order to make coarse thread, and in effect the spinning is performed upon a roving frame with the bobbin and flyer adjusted to give the extra degree of twist.

For making rope yarn and coarse twine an arrangement is made permitting higher speeds, but preserving the same features of gill teeth to separate and smooth the fibres, rollers to attenuate the sliver, and a flyer revolving around the bobbin to insert the twist.

Weaving Yarns. In preparing linen yarn for weaving, the warps are dressed with starch composition, usually at the time that they are being beamed. Mixtures of flour, farina, or Irish moss, with or without tallow, oil, glycerine, and zinc chloride, are laid on by a revolving brush and dried by steam heat and fan currents. Plain cloths are woven upon substantially built calico looms of the Lancashire type, with tappet motions to control the shedding. A great number of jacquards, many of them of large capacity and attached to very wide looms, are at work in the linen tablecloth trade; and for weaving smaller patterns use is made of the dobby.

Jute Looms. Jute looms are of exceptionally heavy construction, with shuttles necessarily large because of the thickness of the weft. The standard jute cloth is 40 inches wide, but much greater widths have to be woven for the oilcloth and linoleum trade. As the weaves are of the simplest patterns, tappet looms are almost universally in use.

As jute is an especially friable fibre, the warps are dressed with flour or mixtures of flour, tallow or lard oil, and alum, and dried by passing between steam-heated cylinders. An increasing amount of dyed jute fabrics is produced for making articles like school-bags, coat-stiffenings, awnings, and wall-coverings, but the greater part of jute piece goods are finished simply by wetting and calendering. In calendering the cloth is threaded through a series of *bowls*, or large rollers, of which alternate ones are heated by steam. The heat and heavy pressure flatten the yarn, close the interstices, and produce a polish, or lustre, upon the face of the cloth.

Jute sacks can be woven as a tubular fabric, and be cut into lengths and sewn, or as a double fabric joined at one side but not at the other, so that after cutting the sides remain to be sewn, and the selvedges form the mouth of the sack. Again, sacks are cut from the piece several thicknesses of cloth at once, by means of a cylindrical cutting machine.

Moisture and Strength. The bast fibres are somewhat hygroscopic, and by international agreement, arrived at in 1875, a *regain* of 12 per cent. of moisture was assigned to flax and hemp, and a regain of 13¾ per cent. to jute. That is to say, that the standard of moisture allows for this recovery of weight after the materials have been reduced to absolute dryness by continued heating at a temperature of 221-230° F.

The yarns and fabrics are stronger when moist than when dry, so that the percentage of moisture affects tests made to determine the tensile strength. Canvas is bought by Government and other authorities under contract of strength, and hence the degree of moisture has importance. Experiments made in the Manchester Testing House upon strips of flax canvas under different atmospheric conditions showed that the same canvas that upon one day would break under a strain of 599 lb. would on a more humid day stand a strain up to 729 lb. The experiments were made under a range of relative atmospheric humidities rising from 44 to 82 per cent.

While in principle the manufacture of flax, hemp, and jute is essentially the same, there are extreme differences in the thoroughness with which the work is carried out and in the calibre of the fibres used for the several purposes. Fine flax is capable of being spun by hand to the fineness of gossamer, and specimens containing 228,000 yards per pound have been produced. A fineness of 64,000 yards per pound is the usual commercial limit, but yarn can be spun by machine to more than twice this length, as is sometimes done for exceptional purposes. On the other hand, jute wefts for cotton bagging are often the thickness of a lead pencil, and are sold in the state in which they leave the roving frame. The contrast is extreme, and is not lessened by remembering that the cost of a fine linen tablecloth may be more than that of the silver and cutlery that are laid upon it in preparation for the meal.

J. A. HUNTER

How the Surface of the Earth's Crust is Moulded by the Agencies of Wind, Rain, and Underground Water.

THE SHAPING OF THE LAND

We have now seen how the rocks have been solidified from their original liquid condition in the great subterranean laboratory. We have next to embark upon the larger, and, in some ways, more interesting, consideration of how they have been changed and moulded on the surface of the earth. The present condition of the world, with its mountain ranges and river valleys, its broad seas and fertile plains, is mainly due to the work of the agencies to which we shall now proceed to give attention. [See also page 287.]

The following table presents, in a convenient form for reference, the *epigene*, or *superficial forces* which have thus modified our planet:

1. Aerial Forces: (*a*) Wind, (*b*) weather, (*c*) changes of temperature.
2. Aqueous Forces: (*a*) Rain, hail, and snow, (*b*) underground water, (*e*) running water, (*d*) the sea, (*e*) ice.
3. Organic Forces: (*a*) Plants, (*b*) animals, (*c*) man.

Those agencies are very simple and natural forces, with which we are all perfectly familiar. They are the forces, in short, of *air*, *water*, and *life*. It is one or other of these three forces to which is due the change of the earth from a barren and fire-swept globe of volcanic rock, upon which no kind of life was possible, to the hospitable and wonderfully fertile planet which we now inhabit.

The Atmosphere. We shall first consider the geological work of the atmosphere. We are accustomed to think of the air as a yielding and impalpable substance, so that it is not easy to realise at first the immense quantity of work which it has done in modifying the face of the earth. We know, however, that air, invisible and subtle as it is, when put into rapid motion, is capable of very destructive effects. The destruction of human property which is occasionally caused by a cyclone or tornado on land, and the wrecks which strew our shores after every storm, alike bear witness to that. The geological effects of wind, which is simply air in motion, have thus to be reckoned with.

The Work of Wind. We can readily see that one of the most important of these effects is the *transportation of matter* from one place to another. The tendency of other natural forces is to wear down the rocks into fine dust or sand. The wind is capable of transporting this fine material for long distances, and not infrequently heaps it up into great masses. Most of the sand dunes which line the seashore in so many parts of the world are simply wind-drifts, which have been pinned down and preserved in a more or less durable form by the growth of wiry grasses and other kinds of vegetation.

That these sandhills are entirely due to wind-drift is clear from the ripple marks which are observable on blown sand, and from the general shape of the sandhills themselves. In the interior of the Asiatic and African continents are found vast tracts of sandy desert, in which the wind has undoubtedly been the main agent in spreading the detritus of the original rocks over vast areas. In the desert of Gobi many ancient cities have been buried deep beneath the steady and inexorable march of the wind-driven sand. The great desert of the Sahara is believed to owe its present extent and nature largely, if not entirely, to the action of the wind.

Blood-rain. The transporting action of wind sometimes covers an almost incredible area. The well-known phenomenon of *blood-rain* is a case in point. The sand of the African desert is raised into the upper regions of the air by local winds, and there meets with the strong and persistent aerial currents which carry it away for scores or hundreds of miles. It is often known to reach the countries on the northern side of the Mediterranean, where its presence is indicated by the fall of rain-showers tinged to a deep red colour by this desert sand, and popularly called blood-rain. The sand of the Sahara is said to have been detected as far away as Boulogne; and in 1901 it was estimated that a vast quantity of sand was transported by wind from Algeria as far as Russia.

Loess. A remarkable deposit, known as *loess*, which is found in many parts of Northern China, covering considerable tracts of ground to a thickness of one or two thousand feet, is believed to be entirely a wind formation. It is a yellowish clay, or loam, and consists chiefly of hydrated silicate of alumina. It contains numerous organic remains, which are mainly of terrestrial origin.

This loess forms an extremely fertile soil, and plays an important part in the agriculture of China. It is found filling river valleys and high up among the hills, in such a position that it is practically impossible to suppose that its site was once inundated by water, and that it was deposited in the form of what we call alluvial soil, which it resembles in other characters. It is almost certain that the loess is the consolidated dust once drifted by the wind from the great plains of Central Asia, which has gradually hardened and accumulated into these vast and deep deposits.

Transport of Life by Wind. The wind is also capable of transporting the minuter forms of life from place to place. These tiny organisms, which are no larger than ordinary grains of sand, are carried on the wings of the wind for vast distances, and find new homes for

themselves when at last they descend to the earth. In this way similar forms of life are found occupying districts very widely separated. There are also well-authenticated instances of the transport by wind of larger organisms than mere seeds or spores. Sometimes a whirlwind or tornado has been known to carry fish in its embrace for many miles, though the showers of frogs, of which we hear every spring in the country, are generally to be received with considerable scepticism.

Atmospheric Erosion. The atmosphere not only transports soil from one place to another, and thus modifies the nature and contour of the earth's surface: it also has a considerable effect in breaking down the hard rocks into dust suitable for such transport. These destructive effects are partly *chemical* and partly *mechanical.* In the first place, rocks are subject everywhere to the operation known as *weathering.* This is a process of disintegration due to the common meteorological agencies. Water in various states is the chief in efficiency among these. But the air itself is accountable for a good deal of rock destruction.

The *changes of temperature* which are constantly occurring have a very important effect upon the rocks which are subjected to them, more especially in tropical countries, where the daily range of temperature between noon and midnight may be as much as 100°. It is a matter of common knowledge that most solid bodies expand when heated and contract when cooled. Thus, railway engineers never lay two rails absolutely touching one another at their ends, but leave room for expansion under the midday sun of summer, otherwise they would bulge out of truth. In the case of natural rocks, where no allowance of this kind has been made by the constructor, the rapid *expansion* and *contraction* which alternate with changes in atmospheric heat frequently cause them to split and throw off fragments. These fragments disintegrate in the same way, and, ultimately, large masses of rock are thus broken down into more or less fine dust, which is blown away by the wind. The effect of this atmospheric disintegration is chiefly seen in the arid plains of the great tropical continents, where there is practically no water present to resist or complicate the process.

41. TYPICAL WEATHERING OF ROCKS

Eroding Action of Sand-laden Wind. There is another way in which wind acts powerfully to break down rocks. Where there is already present sand or fine detritus, which the wind can take up and carry along, we have to reckon with the abrading effects of this dust upon the rocks against which it is driven. The wind thus charged becomes, in fact, a kind of *sand-blast,* such as is used by glassworkers to etch names and figures on their wares. A powerful wind, driving gusts of sand before it, is capable of doing a wonderful amount of work in this way. It has been estimated that a sheet of plate-glass which once formed a window in an American lighthouse was so affected by a wind laden with sand in the course of 48 hours that it was ground completely opaque, and had to be removed. In the deserts of Libya or Wyoming rocks and monuments are found to have a characteristic polish or glaze, which is due to the constant sand-blast to which they have been exposed in every high wind. The deeply pitted marks on the face of the Egyptian Sphinx are similarly due to the abrading effects of the sand-laden wind of the desert.

The Work of Water. The surface of the land has been very largely moulded by the great circulatory system of water, which plays so large a part in our lives. The atmospheric water, in the form of *rain, hail,* and *snow;* the terrestrial water, in the form of *rivers, waterfalls, springs,* and *lakes;* and the marine water, which forms the *oceans;* besides the frozen water which fills the Alpine valleys and covers the Arctic plains with vast *glaciers*—all play a great part in the moulding of the surface of the land.

Atmospheric Water. Let us first consider atmospheric water. There are three states in which water is known to exist upon the earth. It may be *solid,* like ice, snow, or hail; *liquid, gaseous,* as water vapour, or steam. It depends merely on temperature and pressure which of these three forms it takes. There is a vast circulatory system always at work, under the influence of the sun, by which water passes from the great reservoirs of the oceans into the form of water-vapour suspended in the atmosphere, falls then upon the surface of the land as rain or snow, and then, in the form of rivers or glaciers, makes its way back to the sea, thus completing the cycle. It is in the course of these processes that the geological work of altering the surface of the land is very largely done. This work is partly *chemical,* done by the solvent action of water, and partly *mechanical,* done by the movements of the water and the solid matter it carries.

Rain. Rain is absolutely pure water, having been distilled by the sun, when it first passes back into liquid form in the upper air. But as it falls through the air it absorbs a

certain amount of impurities. Among the most important for our purpose is carbonic acid gas (CO_2). Rain also dissolves a small amount of oxygen in its passage through the atmosphere, and it frequently picks up other impurities, especially in the neighbourhood of manufacturing districts, such as nitric acid, sulphuric acid, and organic matter. When the rain falls upon the ground one of two things happens: either it is absorbed, if the surface be permeable, or it trickles along the surface in the direction of the most rapid slope. In the former case it becomes what is known as *underground water*; in the second case it feeds the incipient *rivers*. It is the rain which is absorbed into the rocks which is chiefly responsible for their chemical change, while the rain which flows off into rivers performs the greater part of the mechanical, or erosive action of water.

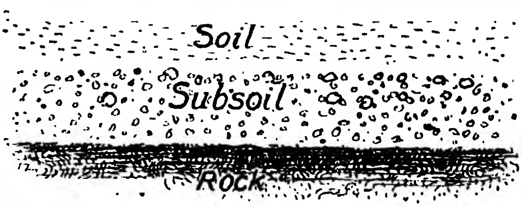
Weathering. The chemical action of rain is mainly responsible for the *weathering* of rocks. This usually signifies a disintegration of the surface due to a chemical decomposition. Some of the hardest rocks are most liable to weathering. Thus, granite frequently decomposes into clay, while the softer limestone keeps a hard surface. Water, by itself, is powerless to affect a large number of rocks, though a few—such as rock-salt—are distinctly soluble in it. But water containing oxygen and carbonic acid gas, as is the case with rain which has fallen a long way through the atmosphere, acts upon a very large number of rocks. Limestones, for instance, are rapidly dissolved by water which contains carbonic acid gas, and are thus gradually worn away, or pitted and drilled, by the action of rain. This is why the mortar of houses requires periodical renewing on the surface, or pointing, and why the inscription on a marble monument generally has become illegible after 40 or 50 years. The wonderful caverns in the limestone districts of Derbyshire and Kentucky have all been carved out by the solvent action of water containing carbonic acid gas.

Oxidation and Reduction. Rain-water generally contains a small quantity of *oxygen* dissolved in it, and this oxygen is able to unite with other elements and form oxides in a much more vigorous fashion than the free oxygen in the air. [See CHEMISTRY.] This process of *oxidation* is what is popularly known as rusting, and the red or yellow crust which is so commonly seen on rocks over which rain has trickled is its product. On the other hand, rain which contains organic matter acts as a *reducing* agent; it decomposes oxides and takes away part of their oxygen, owing to the affinity of that gas for carbon. This is the cause of the white spots or veins so common in red sandstone, where the colouring matter of ferric oxide has been reduced by the presence of some organic matter which is greedy for oxygen.

The great class of *silicates*, which form so large a part, as we have seen, of the rocks which compose the crust of the earth, are readily decomposed by rainwater containing carbonic acid gas. They break down into clay of one kind or another, and in this way granites which have long been exposed to the action of rain are found to have disintegrated or crumbled away for a considerable depth from the surface. There are countless varieties of weathering or meteoric change in rocks, depending on their chemical composition and the nature of the impurities in the water which has run over them.

Rock Sculpture. The weathering of rocks not only alters their composition and hardness, but also has very marked effects upon the general appearance of their masses. No rock is absolutely *homogeneous*; some parts of it are harder than others, some are more readily dissolved or broken down than others. Consequently, after the process of weathering has gone on for a considerable time, the rock is found to have been carved into quite a different shape from that it originally possessed. The softer parts have been eaten away, and the harder ones are left standing up in pinnacles or projecting as boulders. Some rocks, like basalt, weather in a series of crusts like those of an onion, until after a long while the whole mass looks like an accumulation of cannon balls. Granite often weathers into large slabs, which produces the effect of a wall of masonry. In the Cevennes and the Hartz Mountains, the weathering of dolomite and limestone produces masses of stone which look like ruined castles. The tors of Dartmoor are a familiar example of the forms produced by the weathering of granite. A characteristic example of the result of rock weathering is shown in **41.**

Formation of Soil. To us the great importance of the weathering of rocks consists in the fact that it is from their decomposed materials that soil, or earth, is mostly formed. The *soil* originally is simply the weathered, decomposed, and loosened surfaces of the rock over which it lies. There is usually an intermediate stage known as *subsoil* [**42**], which consists of larger broken or loosened fragments of the rock, and which passes upwards into the soil which supports vegetation, and downward into the solid rock. Its nature varies according to the rock from which it has been derived.



42. DIAGRAM SHOWING FORM OF SURFACE EARTH

For a full consideration of the nature of various soils the reader must consult the course on AGRICULTURE. It is enough to say here that all soils practically consist of *sand* or *clay*, or a mixture of these two main substances in various proportions. A fairly equal mixture of sand and clay is known as *loam*, and affords the best soil for agricultural purposes. It is, of course, the

43. A DIP IN THE MOUNTAINS ON THE ROAD TO GRAND CURRAL, MADEIRA, SHOWING THE ACTION OF CENTURIES OF RAIN UPON THE HILLSIDE

addition of organic substances to this soil which chiefly helps to make it fertile. But the actual existence of soil over the whole habitable surface of the earth is due to the weathering, or decomposition, of the primitive rocks by the agencies of air, water, and other meteorological forces.

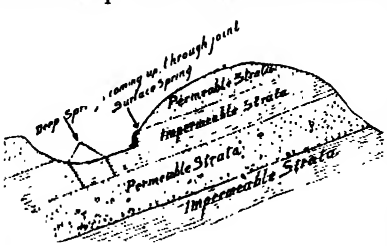
Erosion by Rain. In addition to the chemical action of rain, it also has a mechanical, or *erosive*, action upon the earth. We can readily see of what nature this action is if we go back to the habits of childhood and make a mud pie. Let us go into the garden and heap up a roughly conical mound a couple of feet or so in height; then take a watering-can or hose and sprinkle it with water. Under the miniature rain shower, which runs down all sides of our mound in little streams, we shall see that the looser and more soluble portions of earth are washed away and the sides of the mound are furrowed in all directions by miniature river valleys and stream lines, between which the stones and harder portions of the earth remain standing up. If the rain goes on long enough, one after another of these stones will be undermined and roll down the slope, until ultimately, if we go on watering long enough, the whole conical hill will be washed down into a low mound, of which the greater part is spread over the surrounding earth.

Fantastic Effects of Rain. This simple experiment is a very good object lesson in *the mechanical work of rain.* Wherever it falls faster than it can sink into the ground, it runs down the nearest slope and carries with it a certain amount of soil, selecting, of course, the softest and least resisting parts, and leaving the harder projecting from the ground. Thus, the hillside, though the tendency of rain is steadily to lower it down to the general level of the earth, is usually scoured into more or less irregular forms. If the rainfall is considerable, and the inequalities in the texture of the ground are great, we shall find well-marked torrent-beds which are like stony, sunken paths in dry weather, and become gushing streams in the wet season. This is a very common feature on our British hills. Sometimes, as in the valley of the Tyrol, the stony clay is cut by the rain into actual pillars, which are left standing up because each of them happens to be protected by a huge boulder, which diverts the rain from the ground immediately below it. In other parts, where the soil is all pretty much of the same texture, the whole of a vast stratum may be washed away, leaving only a few relics to tell the geologist that it once existed. It is these inequalities in the erosive action of rain, depending upon the heterogeneity of the soil on which

it falls, that have carved our hillsides and mountain slopes into so many fantastic, wild and beautiful forms [43], besides giving us the greater portion of the soil which smiles with harvest.

Hail, Snow, and Frost. The other forms of atmospheric water—*hail* and *snow, dew* and *hoarfrost*—call for little notice from the geologist. The effects of melting snow are practically the same as those of rain, except that when a large deposit of snow melts rapidly it, of course, gives birth to more considerable torrents than an ordinary rainfall can produce. The work of snow-fed glaciers, which is one of the most important factors in geological history, is separately considered in a later chapter.

Underground Water. We have seen that rain falling on the ground either sinks into the surface or runs off. Which of these events happens depends on the relative permeability of the surface of the ground and the heaviness of the rainfall. If the rain fall on a surface like granite or a street pavement, it all runs off and joins a river or a gutter. If it fall on a surface as permeable as loose sand or ordinary grass-land, it nearly all soaks in; and, of course, every intermediate stage is found to exist in Nature.



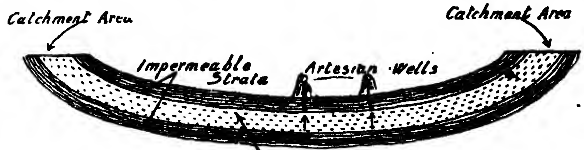
44. DIAGRAM SHOWING WATER SPRINGS

We shall first consider the rain which soaks into the earth and forms *underground water*.

Springs. The law of gravity causes rain to go on descending by its own weight as far as it can. Sooner or later, as a rule, it will reach the limit of permeable strata and bring up against the underlying stratum of impermeable rock. If this bed lie on a slope, as is usually the case, the water runs down this slope, forming, so to speak, an underground river, though it must not be supposed that it is usually so well defined as a surface river; it is rather a great mass of saturated sand or gravel, like a sponge full of water. If this underground reservoir, as we may call it, find an opening to the surface of the earth at a lower level than that of its own surface, the water will there emerge as a *spring* [44], which will flow steadily so long as the level of the water in the underground reservoir does not fall below the point at which the spring emerges. If, in a season of drought, no rain fall to keep the underground reservoir full, and the water ultimately fall below the level of the spring, the water will cease to flow, until a new rainfall again fills up the reservoir. In all countries where there is a regular rainfall the permeable rocks are found to be saturated with water below a line known as the *water level*, which is fairly constant, but rises or falls slightly with a wet or dry season. A *well* is simply a hole dug into the earth below this line, so that the water trickles down into it and keeps it full up to the water level. An *artesian well* [45] is a well sunk through an impervious surface bed, such as clay, down to a porous stratum which lies beneath it. It often happens that this porous stratum slopes down from the surface of the earth at a considerable distance away, and its *catchment area* may be higher than the point at which the well is sunk. If this be the case, when the well reaches the porous stratum the water will gush up to the surface, and even rise in a fountain under this hydrostatic pressure, just as a garden hose will throw a jet considerably above the level of its tap.

Hot Springs from the Earth's Kitchen Boiler. Many springs emit hot water, which in volcanic districts may even be boiling. They are found in our own country, which is far from any volcanic centre, as at Bath, with a temperature as high as 120° F. These have clearly risen from a great depth, where the water has been heated by its proximity to the earth's kitchen boiler. They are natural artesian wells [45], in which the flow of the water is due to the fact that its channel communicates with some catchment area at a higher level than where the spring comes to the surface—that of Bath is possibly on the Cotswold Hills. The common distinction between *deep-seated* and *surface* springs is merely one of degree, depending on whether the water emerges by a simple descent through the subterranean strata—*e.g.*, from the top of a hill to the valley—or is forced up by hydrostatic pressure through a natural syphon. Nor is the distinction between *constant* and *intermittent* springs of any great importance, except to those who get their water from them.

Mineral Springs. All spring water, however clear and pure it may appear, contains various impurities in solution. These consist of dissolved gases and minerals, derived from the rocks through which it has passed. When the water has descended low enough to be considerably heated, its solvent powers are, of course, increased. *Mineral springs* are so called when they contain a marked amount of minerals in solution. Thus we have *petrifying springs*, the waters of which contain so much calcium carbonate as to deposit it in a white crust on the substances over which they flow. They are common in limestone districts, where they dissolve the limestone underground with the aid of carbonic acid gas, and deposit it when they reach the surface, and the carbonic acid gas evaporates. *Chalybeate springs* contain iron compounds, chiefly in the form of various



45. DIAGRAM SHOWING THE CAUSES OF ARTESIAN WELLS

46. THE SCENE OF A GREAT LANDSLIP NEAR LYME REGIS, DORSETSHIRE

sulphates. *Brine springs* are impregnated with salt, derived from beds of rock salt in the earth beneath. There are various kinds of *medicinal springs*, which may be alkaline, as at Vichy; bitter, as at Kissingen; salt, as at Wiesbaden; limy, as at Bath; or sulphurous, like the well-known "rotten-egg" water of Harrogate. These are often warm, or *thermal*, springs.

Underground Caverns. The chemical action of underground water consists mainly in dissolving the various substances which are then brought up to the surface by springs. It is obvious that if this considerable amount of material is brought up from beneath the earth's surface—some limestone springs have built up actual hills—there must be a vacant space left where it was removed. Thus we find that considerable subterranean *caverns* and *tunnels* are formed by the solvent action of underground water. This is particularly noticeable in limestone districts, where vast systems of caves have been hollowed out during the lapse of ages. The caverns of the Peak in Derbyshire and the Mammoth Cave in Kentucky are famous instances. Not infrequently the roofs of these underground caverns collapse when they come too near the surface, and *landslips*, or *subsidences* of the ground, must take place without warning. The meres of Cheshire chiefly occupy places where the land has subsided in consequence of the washing out of the underlying beds of rock salt. Some earthquakes are probably due to the shock caused by the falling in of the roofs of the deep caverns.

Landslips. Underground water has not only a chemical, but also a mechanical action. It acts as an *erosive*, no less than as a *solvent*. This is especially the case where water runs through a porous stratum sloping under a mountain or hill. The material of this stratum is gradually washed away, until it becomes unable to support the overlying strata. The ultimate consequence is a *landslip*. A great part of the English coast is marked by the remains of such landslips, which form a picturesque feature, known as the *undercliff* [46]. A large part of the town of Sandgate was destroyed by such a landslip in 1893. Landslips in mountainous and rainy countries are often far more destructive than any that we experience. The traveller by the St. Gothard Railway still notices the huge scar on the side of the Rossberg which marks the place where the whole side of that mountain slipped into the valley after the rainy season of 1806, burying four villages with their inhabitants. The percolating water in such cases not only weakens the strata through which it flows, but also acts as a lubricant, and thus a great mass of rock begins to slide when its weight finally overcomes the power of cohesion. Destructive landslips are not uncommon in India, and about 150 have been recorded in Switzerland. In Ireland we occasionally hear of a similar phenomenon, known as a *bog-slide*, when the whole surface of a bog, or peat-moss, becomes so saturated with water that it breaks down its moorings and flows bodily downhill.

W. E. GARRETT FISHER

Casting from Complicated Patterns. Cored Work. Loose Pieces. Rapping. Taper. Cores. Core and Drop Prints. Shrinkage.

PATTERNS AND CASTINGS

In the last article we selected cast objects of forms so plain that there was nothing to complicate the delivery of their patterns from the moulds. That is, there were no portions overhanging in the lower parts of the moulds, with overlying sand that could interfere with the ready withdrawal of the patterns. Everything was tapered downwards, and only one sand joint was required between the top and bottom portions of the moulds. But such simple examples only constitute a small portion of the moulder's work. So now we take up some illustrations of castings in which a good many problems not so simple are involved.

Flanged Castings. The figures from 20 to 25 show castings and methods which have resemblances and differences. In castings 20 and 23 there are flanges, one of which, if fast in the bottom of the mould, would prevent delivery of the pattern from the sand. In each there are central bosses; in each there are alternatives that are practical. We will dispose of the bosses first, because only a few remarks thereon are necessary.

The difference between those in 20 and 23 is that the space for sand left between the bosses and the inside edges of the rims is very small in 20, but ample in 23. It would be difficult to lift the sand out of the narrow zone in the former but easy to do so in the latter. The top portion of the boss in 20, therefore, must be attached loosely to the plate of the pattern 21, in this case with a central stud, to come into the sand of the top, and be withdrawn after turning over. But it is not necessary to do so in 24, although it is often done as shown, in order to avoid risks of a breakdown of the sand. Note may also be made of the large amount of *taper* given both to the bosses and to the internal portions of the rim in 21, with a view to easy delivery, though it happens also to coincide with the best form for strength.

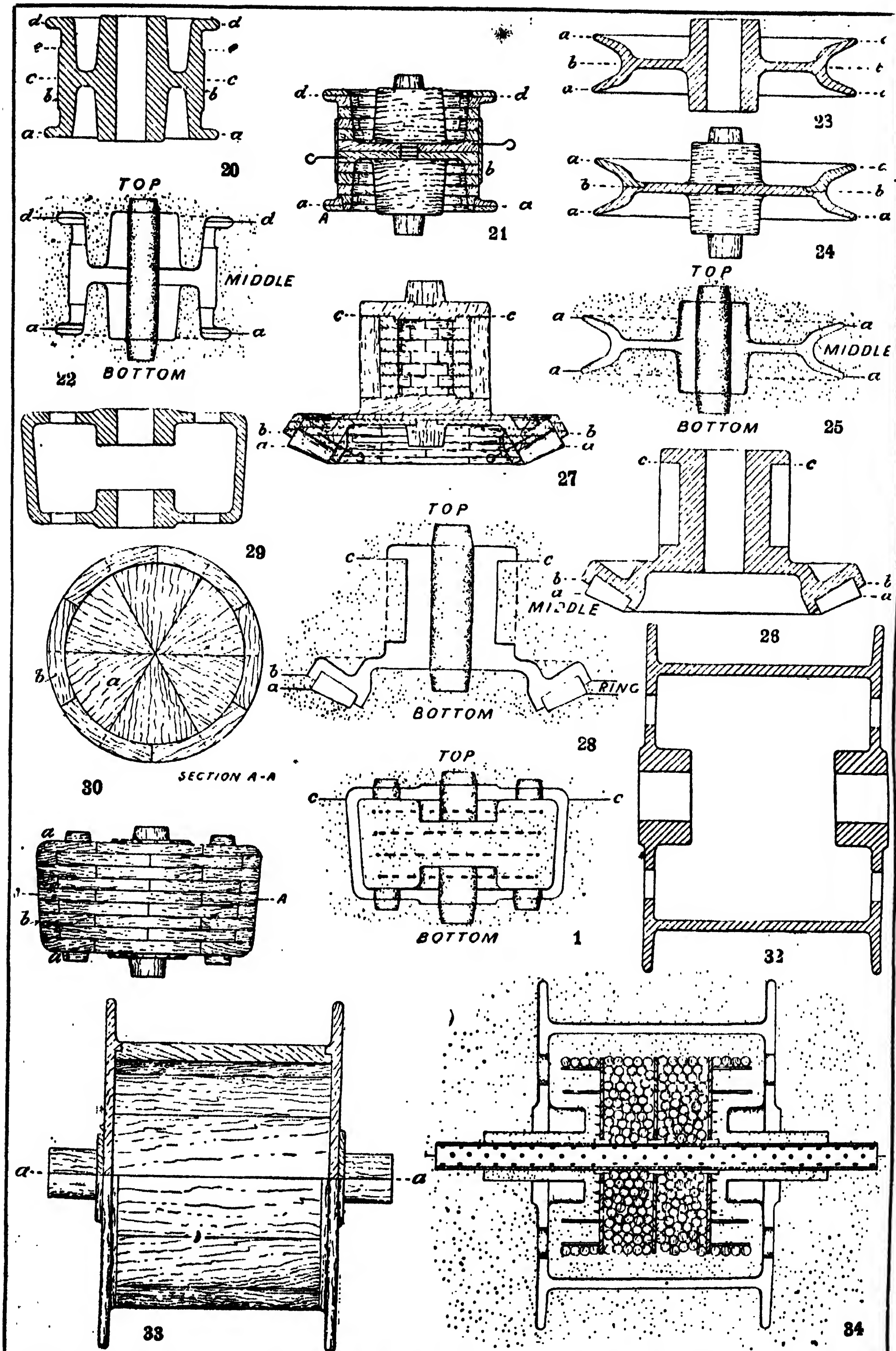
Joints. With regard to the delivery of the lower flanges, it is necessary in 20 that the mould should part along *a—a*, so that the lower flange can be taken out after the removal of the top mould and pattern. In that case, the annular tread (*b*) must be fitted loosely in segments round the body of the pattern 21, to be left behind on the withdrawal of the latter, and to be pulled inwards subsequently in a horizontal direction. Or, leaving the projecting portion (*b*) loose might be avoided by jointing the pattern along the plane *c—c* [20]. In that case both flanges would have to be left loose, and sand joints made along the planes *a—a* and *d—d*. The only objection to this is the making of an extra sand joint.

The pattern 21 has its bottom flange (A) as a loose ring. The belt (*b*) is fitted in short lengths, and retained with skewers loosely. The method of building up shown is that adopted in work of this class, to which reference is made in the next section. The mould in 22 comprises now not only a top and bottom, but a *middle* part, requiring a moulding box in three corresponding sections.

Alternatives in Joints. In 23 the sand joints required are two, along the planes *a—a a—a*. To produce these the pattern [24] is differently jointed, either along *b—b*, through the middle, or along one face of the plated centre, one half of the sheave being then fitted as a ring, as shown. This may be a wooden pattern, in which case it is built in segments similarly to 21. Or, as is often done for repetitive work, an iron or brass pattern is made with wooden bosses, interchangeable by means of their central studs. This is the pattern shown by way of alternative in 24. Another alternative is to core the rim out, using an annular print; but that method is rarely adopted, except in the case of wheels that have recesses for chain, and not always then, cores being generally reserved for wheels of large diameter. The device is also employed when broken castings have to be moulded from, in which case a segmental print is rammed round the casting in the mould in successive positions until the circle of the print impression is completed.

Fig. 25 gives a section through the cored mould, with the two joints at *a—a*, leaving a middle ring of sand.

Three-part Joints. Fig. 26 illustrates a bevel wheel and a spur pinion cast together, and both *double-flanged*. Such an example cannot be drawn from the mould unless there are three joints in the sand, at *a*, *b*, and *c* respectively. It is a job for a *three-part* box, not four, as might be imagined, because the thickness from *a* to *b* is made in segmental cores, which involves less trouble than using a shallow moulding-box for the purpose of jointing. For convenience, the pattern in 27 is made with a greater number of joints than the mould, the object of which is to give perfect facilities for ramming, and also for ready delivery of the pattern parts, with the minimum of risk of tearing up the sand. The section of the pattern in 27, by comparison with the casting in 26 and the mould in 28, renders the nature of the work apparent. We have loose pieces again in the shroudings for the teeth, and in the separation of the pinion from the bevel wheel.



20. Double-flanged wheel 21. Pattern for No. 20 22. Mould for No. 20 23. Sheave wheel 24. Pattern for No. 23 25. Mould for No. 23 26. Bevel and spur-wheel cast together 27. Pattern for No. 26 28. Mould for No. 26 29. Roller casting 30. Pattern for No. 29 31. Mould for No. 29 32. Crane drum 33. Pattern for No. 32 34. Mould for No. 32

Cored Work. Fig. 29 is an example of a different kind from the foregoing, illustrating cored work in which the main core is completely enclosed within the body of the casting.

The roller in this figure is moulded, not as it runs, but flatwise, with its plane faces in top and bottom; not that it could not be moulded edgewise, but because the flat position renders the insertion of the cores easier. The pattern in 30 is built up in segments, the top and bottom sets (*aa*) covering the entire faces, the middle ones (*b*) being narrower and annular. The prints (*a*) will be noted as corresponding with the holes in 29. There is only one joint in the mould, that at *c—c* [31].

The main core for 29 is made in a box, rammed in core sand and dried. Generally, though not always, the shaft holes are made in cores distinct from the body core, as shown in the mould in 31. The small holes seen in the end plates in 29 and 31 are inserted simply to provide openings through which the core and core irons can be withdrawn after casting. When these are not inserted the work of the fettler is increased unnecessarily. In 31 the core is seen to be built round a skeleton of rings of iron rod.

Drum with Swept-up Core. The drum casting in 32 is moulded as it runs, with its cylindrical axis horizontally, differing in method, therefore, from 29. One reason for this difference is that the flanges on the drum may "lift" from the sand without being left loosely, while the roller [29] has no flanges, but a good coning, which makes the flat way of moulding the obvious one. The pattern is shown in 33, in half external view, and half section, *a—a* being its joint, corresponding with the mould joint. It affords an example of a method of construction termed *lagging up*, of which more later. The flanges, with boss, facings, and prints, are turned separately from the lagged body, and screwed on its ends.

Fig. 34 is a section through the mould. The core in 34 is swept on a bar—using "hay ropes" and loam—around skeleton core plates, the loam being in a plastic state, the whole mass being dried subsequently before insertion in the mould. When thus swept up, the cores for the shaft holes are swept up also on the bar, and the bar is stiff enough to sustain the weight of the core when laid horizontally in the mould. When a core is made in a box, as for 31, it is not so well able to sustain its weight as when a bar is used.

The engine crosshead in 35 may be moulded in the manner shown [38], or flatwise. The choice is so evenly balanced that crossheads are commonly made either way. The pattern with its prints is shown in 36, the core box in 37, and the finished mould in 38. Observations on the relations of the parts would be superfluous.

Engine Cylinders. These are more elaborated in the cores than in the moulds. Every different design of cylinder presents a distinct set of problems, which has to be tackled irrespective of other types. A comparatively plain example is given in cross-section only [39], being one for a particular type of steam crane. Fig. 40 is its pattern, 41 its mould; moulding as shown. Joints are made in the mould at *a—a*, *b—b*, and *c—c*; but only *a* and *c* coincide with the joints of the moulding box, the spaces between *b* and *a* being taken out by means of "false cores" or "drawbacks." There are thus six cores in this example [41], the main one (A) for the bore, the two false cores (B, B), two passage cores that do not come in this view, and one exhaust core (C), through which the sections are taken. The pattern for this [40] has to be jointed along *a—a* and *d—d*; while the feet over which the false cores are rammed are loosely attached to the cylinder body with screws, to be left behind in the mould until the false cores are lifted, after the delivery of the corresponding half of the pattern body, to which they are attached loosely.

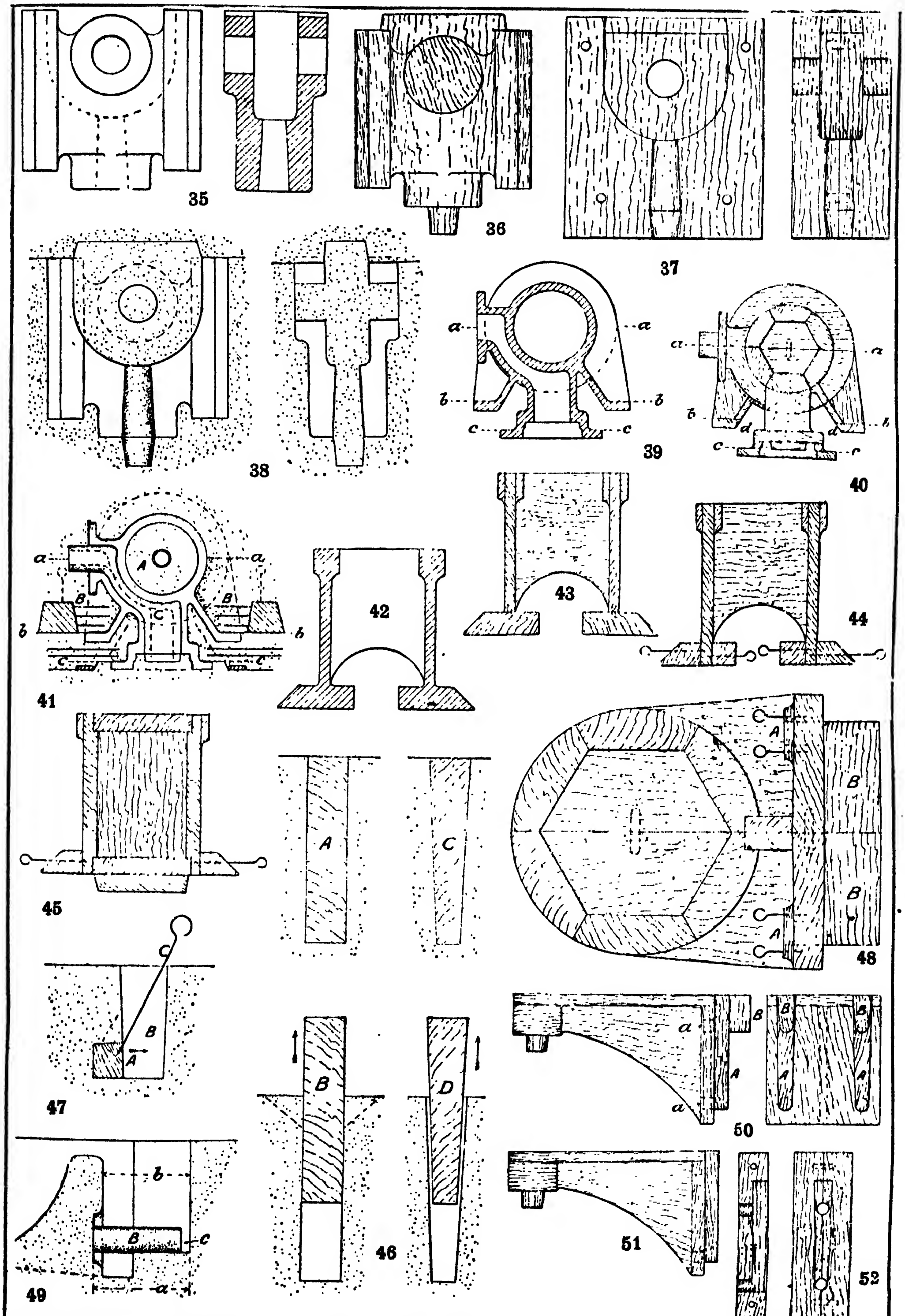
Methods of Delivery. These examples afford a good selection of typical cases of moulding, and we shall occupy some space with further elucidation of some important matters that have been only touched on in passing. We have spoken of the necessity for making provision for getting patterns out of their moulds. This involves not only the jointings shown, but the fitting of loose pieces, and of drawbacks.

Loose Pieces. It is obvious that the mere vertical direction of withdrawal does not cover the case of patterns having portions standing out perpendicularly to those faces, or at angles therewith. Several examples of this kind occur in the figures preceding, in which *loose pieces* are fitted. This term signifies that pieces which cannot be drawn out with the main portion of the pattern without tearing up the sand mould that overlies them are attached loosely, being left behind to be withdrawn subsequently to the main portion. These loose pieces are fitted in many ways, by *skewers*, or *wires*, or loose nails—*i.e.*, nails that are not driven entirely in, but partly only, and so hold temporarily, and also by dovetails. The one essential is that the loose pieces shall be maintained in their exact location during ramming, which is the function of the skewers, nails, or dovetails. The moulder has to withdraw skewers or nails, when sufficient sand has been rammed round the loose pieces, to secure them in relation to the main pattern, but dovetails free themselves in the act of lifting.

Often loose pieces are held temporarily with dowels. A common lathe-bed, shown in section [42], will, with previous examples, illustrate typical methods of this kind.

A lathe-bed of the section in 42 may be made to mould in three ways equally well, as shown in 43 to 45, which give sections through the patterns. In 43 the bed faces are doweled on the bottoms of the ribs, in 44 they are wired at the sides, in 45 the outer pieces are wired, and the interior cored out, for which a print is provided.

A *drawback* [41*bb*]—the *false core* of the brassfounder—is a little mould within a mould, and fulfils a similar function to the loose pieces—that is, it carries sand that overlies projecting portions of patterns. It is adopted as an alternative, but is also more generally employed when loose pieces would not be suitable, on account of the great width of overhang.



35. Crosshead casting **36.** Pattern for No. 35 **37.** Core-box for No. 35 **38.** Mould for No. 35 **39.** Cylinder casting in section **40.** Section through pattern of No. 39 **41.** Section through mould of No. 39 **42.** Lathe-bed in section **43-45.** Alternative methods of making pattern for No. 42 **46.** Diagram to illustrate taper **47.** Taper in a loose piece **48.** Drop or pocket-print **49.** Core in impression of drop or pocket-prints **50.** Drop-prints superimposed **51.** Single-print thickness for two holes **52.** Core-box for ditto

Rapping. The *delivery* of patterns, as their withdrawal from the sand is termed, is accomplished by the assistance of *rapping*, for the purpose of loosening the pattern from its surrounding sand. It is effected by inserting a pointed iron bar in the top of the pattern, or in a hole in a special form of plate attached to the pattern, and then striking the bar in lateral directions. The pattern being thus *loosened*, is *lifted* with a screw, and during the process rapping is continued with a wooden mallet on the pattern face to detach it more effectually from the sand.

A result of rapping is that the mould becomes slightly enlarged, and in the hands of careless moulders this often results in inaccurate castings and in badly broken moulds. It is in this work of withdrawal that the moulding machines give superior results to handwork, because the lift is absolutely perpendicular, and the rapping required is nearly nil; or it is often avoided altogether by drawing the pattern through a plate, having a hole cut to the same outlines as that of the pattern, and which holds the sand down, hence termed a *stripping plate.*

Taper. We have said little yet about an important matter to which slight allusion has been made, though it is illustrated in nearly every preceding drawing—that of *taper, draught*, or *strip*, as it is variously called.

The way in which taper assists the delivery of a pattern is clear from **46**, in which the withdrawal of a quite parallel piece is contrasted with that of a tapered piece.

The parallel piece A, though drawn halfway out of the mould, as at B, is still as tightly confined by the sand as at first. The tapered piece C, on the contrary, similarly withdrawn, D, is entirely clear of the sand, and requires no effort to withdraw it through the remainder of the way. In B the sand will assuredly become fractured along the course of the dotted lines; while at D no fracture worth mentioning, probably none at all, will occur.

Even though there is taper in a pattern, the pressure and friction of the sand against the deep faces is so great that they could not be withdrawn without fracture of the sand unless the patterns were slightly loosened first by shaking or rapping them.

Amount of Taper. With regard to the amount of taper required no rules can be given. It is a matter for judgment, to be decided in the case of each individual piece of work. Still, some idea can be given of its amount.

If a rib like **46** be 1 ft. deep, the taper will usually range from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. That is, the wood will be from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. thinner at bottom than at top. If a rib were 2 ft. deep, the taper would range from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. If 6 in. deep only, from $\frac{1}{32}$ in. to $\frac{1}{16}$ in. would be given. If 3 in. deep, $\frac{1}{32}$ in. would suffice; if 1 in. deep, the removal of a mere shaving would be sufficient.

Again, take the case of a loose rib which has to be withdrawn, as A in **47**, into the space B of the mould, with the pricker C held in a diagonal direction. In such cases taper much in excess of that given to vertical ribs is imparted, because the withdrawal is an awkward task, and if the sand breaks at the dotted line, as it is likely to do, it is difficult and troublesome to mend it up.

When the top portion of the sand of a mould has to be lifted off a pattern, the amount of taper required is greater than when the pattern is lifted from the sand.

Cores. The formation of hollow spaces is the function of "cores," using the term in its broadest sense. Parenthetically, we may note that the term *core* strictly relates to something made apart from the mould, and inserted subsequently. It is usually dried, but not invariably; if not, it is often termed a *green sand core.* If a piece that fulfils the function of a core be rammed in the mould, it is termed a false core, or *drawback.*

The methods of making cores are broadly divisible under three heads. Since any internal body of sand, as distinguished from external portions, is a core, the first method is that in which internal portions are delivered from the pattern, or self-delivery. But in the greater number of cases the core is rammed in a box separate and distinct from the pattern. The box encloses its sand, and, therefore, as in patterns, provision must be made for the removal of the core from its box without sustaining damage. Hence most boxes are divided in one or more planes, and the same devices of taper and loose pieces must be embodied in many boxes, as in patterns when identical conditions of delivery arise. Examples of boxes are given in **37** and **52.**

Loam Cores. The third great class of cores comprises that in which sweeping up in wet loam is adopted, as in **34.** It is applicable to heavy circular work, and to *strickled* work. The object often is to save the expense of making a large core box, but there are many cases in massive work in which a core rammed in sand would not be practicable. The loam is plastic, and is swept on a skeleton built upon a revolving core bar, and afterwards dried. In strickled work loam is still swept around a skeleton-like framing, but instead of a revolving bar, a guide iron, or the edge of a core plate becomes the guide to the movements of the strickle.

Core Prints. As a core has to be made separately from its mould, it is usually necessary to make provision to ensure its exact setting in the mould. This is the function of *core prints*, the forms of which are varied to suit the direction in which the core has to be inserted, its mass, or area, and other conditions. Core prints are put in top and bottom of patterns and moulds, or at the sides. In the latter position they often take the form of *pocket*, or *drop prints*, to avoid having to make a sand joint down to the centre of the print. Then the upper part of the drop print is filled up with sand after the insertion of the core, or the core box is made of such a shape that the core shall fill it up, or *stop itself off.* Numerous examples of cores set vertically are given in the preceding figures of core prints, but some further remarks are desirable relating to those in th-

horizontal position, which are carried in drop or pocket prints.

Drop Prints. Take the case of the lagged-up cylinder pattern, shown in section **48**, with holes to be cored through the bolt bosses (A A) skewered on the inside of the foot, the drop prints being shown at B B. Looking at a section through one-half of the mould [**49**], a core (B) is made, and dropped into the mould. This core cannot be made of the full length (a) over print and boss, and dropped down into the mould through the narrower width (b). To put a pocket print on the same side as the boss would give trouble, which is avoided by making the prints B B [**48**] sufficiently thick to more than counterbalance the weight of their cores. Then, making the core B only of the length b in **49**, it is dropped down into position, and then slid along to touch the face of the boss, as shown, afterwards filling up the space c with sand to keep it from shifting.

Not infrequently it happens that two or more holes are required horizontally in a plate, one above another, as in **50**, which represents a pattern in side and end elevation, with the pocket prints for coring out the holes, the positions for which in the casting are indicated by dotted lines at a a. In such cases the prints are either superimposed (A B) or a single print is used, as in **51**, and a special core box made.

When two prints superimposed are used the outer one should be made a little thicker than the one which goes next the pattern, to afford sufficient guidance for the top core, which has to pass across a greater distance than the bottom core. This is indicated in **50**.

Fig. **52** shows a core box in plan, and opened in the joint face, for coring both holes with a single print.

Distinction Between Cores and Bosses. A natural question is, how is the moulder able to distinguish these core prints, which are not parts to be cast, from bosses, which have to be? Mistakes have often occurred in this way. Thus, a moulder not recognising the function of a roller in the pattern of **16**, might cast the prints a on if a core box were not sent him. He could not make such an error in **36**, having a core box, **37**. Frequently in large patterns, bosses and prints are numerous and look alike, and it is not usual to send boxes for plain cores. Error is prevented in shops where a good system exists by varnishing or painting prints differently from the body of the pattern. Generally, clear yellow shellac varnish is used for the patterns, and black for the core prints. This is often carried a stage further. Patterns for brass are distinguished from those for iron by varnishing the bodies black and the prints yellow.

It is often necessary to make moulds with certain portions lowermost, to ensure sound, clean metal in surfaces which have to be planed, or otherwise machined bright. Such faces are painted red, or other distinctive colour. The lathe-bed [**42**] is a case in point. These are always cast upside down, as indicated in **43** to **45**. Here the loose pieces render the method obvious. But often there is no distinctive feature of this kind to guide the moulder, hence the advantage of colouring red.

Shrinkage. One other matter calls for consideration here. All the common metals and alloys shrink as they cool down from the molten state. Unless the mould were made larger than the required dimensions of the casting when cold, the latter would be too small. So that all patterns are made of larger dimensions than their castings by this amount, and this, again, varies in quantity in iron, steel, brass, gun-metal, aluminium, and not only in the different metals, but in metal of the same name in different compositions, and under diverse conditions of casting.

The following table embodies averages for the common metals and alloys:

SHRINKAGES OF CASTINGS.

Cast iron, average $\frac{1}{8}$ in. in 15 in.; light castings, $\frac{1}{8}$ in. in 16 in.; heavy and mottled, $\frac{1}{8}$ in. per 12 in.; work mainly cored, $\frac{1}{8}$ in. per 12 in., or less.

Malleable cast iron, $\frac{3}{16}$ in to $\frac{1}{4}$ in. per 12 in.

Bronzes and brasses, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. per 12 in., depending on composition and on mass.

Steels, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in 12 in. Heavy castings shrink most, light ones least.

Aluminium, $\frac{1}{4}$ in. in 12 in.

Copper, $\frac{3}{16}$ in. in 12 in.

Lead, $\frac{3}{16}$ in. to $\frac{5}{16}$ in. in 12 in., depending on its degree of purity.

Tin, $\frac{1}{8}$ in. in 12 in.

Patterns for Different Metals. A question that arises not infrequently in most shops is this: Castings are wanted off the same patterns at different times in iron and in steel; and in the smaller pinions, also in gun-metal or phosphor-bronze. As the shrinkage of these varies, the foreman who has to give orders for each in turn has to attempt to reconcile the irreconcilable. The difficulties have to be got over by these methods.

For standard work, where correct pitch diameters must be maintained, separate patterns must be made for cast iron and steel. But the latter will serve also for gun-metal and phosphor-bronze. In very small pinions not exceeding, say, 6 in. in diameter, the difference in shrinkage may be neglected, but over that size it becomes very marked. In fact, a heavy, solid pinion of 10 or 12 in. diameter will show a higher rate of shrinkage than a larger wheel with arms. For large steel wheels the moulding-machine offers advantages over pattern-moulded gears, especially when gears are shrouded.

An advantage of making a separate pattern, or a special set of pattern parts for machine moulding for steel, is that the sections can be lessened, steel being stronger than iron.

When exact centres are not important, then these steel wheels can be cast from patterns made for iron, and though the difference in diameter may amount to several eighths of an inch in a wheel of fair size, yet the pitch will be practically unaffected.

JOSEPH G. HORNER

Spanish: Impersonal and other Verbs. German: Strong Verbs. Plural of Nouns, Conjunctions. French: Imperfect Indicative.

SPANISH Continued from page 2492

By José Plá Cárceles, B.A.

Impersonal Verbs. Impersonal verbs are those which can only be conjugated in the third person singular of each tense, such as *tronar,* to thunder; *nevar,* to snow.

Translation of "there is." The various tenses of the form "there is" are rendered by the third person of *haber*, with the single exception of the present indicative, which is translated by *hay* instead of *ha.* The student must bear in mind that *haber,* being in this case an impersonal verb, cannot be conjugated in the plural.

Thus "there is" and "there are" are both rendered by *hay;* "there was" and "there were" by *había*, and so on. As, however, *haber* thus conjugated only implies existence, whenever "there is" or "there are" expresses the place where persons or things are, *allí está, allí están* must be used instead of *hay.—allí está mi libro,* there is my book.

When "any," "some" or "none," used in connection with any tense of the impersonal form of "be," refer to a previous noun, those words are generally rendered by *lo, la, los, las,* according to the gender and number of that noun.—*beberé vino español si lo hay,* I shall drink Spanish wine if there is some.

"To be cold, hot, sunny, windy," and so on are translated by *hacer frío, calor, sol, viento,* and so on.—*hace demasiado calor,* it is too hot; *hacía viento,* it was windy. The past definite, future, and conditional of *hacer* are irregular, the third person singular of these tenses being *hizo, hará, haría.*

"Ago" is rendered by *hace.—hace tres semanas,* three weeks ago.

"To be necessary" may be translated either by *ser necesario, ser menester, ser preciso,* or by the impersonal verb *haber que.—para aprender un idioma extranjero hay que* (or *es preciso, menester, necesario*) *estudiar muchísimo,* in order to learn a foreign language it is necessary to study very much.

"Must" and "Ought." The defective auxiliary "must" may be rendered either by *deber, tener que,* or *haber de.—debo* (*tengo que* or *he de*) *terminarlo hoy,* I must finish it today.

"Ought" is translated by the conditional tense of *deber.—debería cambiarlo,* he ought to exchange it.

EXERCISE XXXV

the people	*la gente*	the deck	*la cubierta*
free	*libre*	cabin	*camarote*
to hail	*granizar*	often	*á menudo*
seldom	*raramente*	splendid	*espléndido*
to dawn	*amanecer*	almanac	*almanaque*
umbrella	*paraguas*	to drizzle	*lloviznar*
in time	*á tiempo*	fog	*niebla*
reply	*respuesta*	fault	*culpa*
gold	*oro*	affair	*asunto*
safe	*seguro*	to grow dark	*anochecer*
it looks like rain	*parece que vá á llover*		
it does not matter	*no importa*		
summer holidays	*vacaciones de verano*		
all the same	*de todos modos*		
on the fore-deck	*á proa*		
of course	*naturalmente*		
to rise (the sun, the moon)	*salir (el sol, la luna)*		

1. There are many reasons to (trs. *para*) suppose that. 2. There were too many people on (the) deck. 3. Is there anybody in that cabin? 4. I think so, but there are several free on the foredeck. 5. There is no time to (trs. *que*) lose. 6. There will be more the day after tomorrow. 7. It only rained the two first evenings. 8. Does it hail often in your country? 9. Very seldom; the last time that it hailed was five years ago. 10. Yesterday was (*hizo*) a splendid day. 11. At what time does it dawn now? 12. According to the almanac, the sun rises at a quarter to six. 13. In winter it grows dark earlier than in summer. The days are very short. 14. It is too hot in this room; please open that window. 15. With pleasure, but it will be too cold. 16. It does not matter. I thank you very much, all the same. 17. Please lend me an umbrella. It looks like rain. 18. I think it is drizzling already. 19. Was it sunny during your summer holidays? 20. On the contrary, we had fog almost every day. 21. There is your friend's motor-car. 22. It will be necessary to explain it to him again. 23. He must have forgotten it. 24. I saw him two weeks ago. 25. We must wait for his reply to (trs. *para*) see whose (trs. *de quien*) fault it is. 26. They ought to pay us in gold. 27. Do you not think I ought to put the affair in (the) hands of my lawyer? 28. Of course. It would be much safer for you.

Construction required by "gustar" and "faltar." There are some Spanish verbs like *gustar,* "to like" or "to please," *faltar,* "to want" or "to be in want of," *pesar,* "to be sorry," and a few others, which require a construction of the phrase absolutely different from that which is used in English. In sentences of this kind the person, who in English is the subject, becomes the object, while this latter becomes, in a manner, the subject, of the Spanish verb. Thus, for instance, "I like that book" must be rendered by *aquel libro me gusta* (lit., that book pleases me); "he wants time" by *le falta tiempo* (lit., time is wanting to him); and "I am sorry to have written to him" by *me pesa haberle escrito.*

"How," used in questions formed with the verb "to like," is always omitted in Spanish, and the present participle, which sometimes represents the object of the sentence, must be translated by the infinitive.—*¿ Le gusta á Vd. viajar ?* How do you like travelling ?

Hacer falta is very frequently employed instead of *faltar.—me hace falta otro empleado,* I want another clerk.

Present Participle and Preposition. A present participle immediately preceded by a preposition must be rendered in Spanish by the infinitive.—*despues de haber comprado el billete,* after having bought the ticket; *sin pronunciar una palabra,* without uttering a word.

"So" and "Very." The words "so" and "very" are translated by *tan* and *muy* in front of adjectives, adverbs, and past participles preceded by *ser* and *estar,* but they are rendered by *tanto* and *mucho* whenever they qualify a noun or a verb.—*no estoy tan cansado como Vd.,* I am not so tired as you ; *no hace tanto frío como ayer,* it is not so cold as yesterday.

"Very much" must be rendered by *muchísimo* and "so much" by *tanto.*

KEY TO EXERCISE XXXIII

1. Se alegró de verme. 2. Espero que se divertirán Vds. 3. Se acostaron tan tarde porque tuvieron que aguardar á su padre. 4. No nos sentamos durante toda la noche. 5. ¡ Sería tan fácil equivocarse ! 6. No se moleste Vd. 7. El cajero se enfada mucho cuando nos equivocamos. 8. Bájense Vd. enfrente del Palacio Real. 9. Pronto se cansarán si andan tan de prisa. 10. No nos despertábamos hasta las siete y media. 11. ¿ Cree Vd. que se retirará del negocio el año que viene ? 12. Creo que se retirará si su hija se casa con su socio. 13. Decídase Vd. 14. Me resfrié en la playa. 15. ¿ Se bañó Vd. ? 16. No, no sé nadar. 17. Nos estableceríamos cerca del Mercado Central. 18. Se aprovecharon del gran aumento en la demanda para subir los precios. 19. Se alababa demasiado. 20. Tuve que despedirme de todos mis amigos. 21. Se reirían. 22. Nos negamos á aceptar sus condiciones. 23. ¿ Dónde puedo lavarme ? 24. Se parece á un amigo mío. 25. Los soldados se alojaron en las casas de la aldea. 26. Nos mudamos á esta casa algunos días despues.

KEY TO EXERCISE XXXIV

1. Se cree que son más de diez. 2. Se comentó la noticia. 3. Se compran, se venden y se cambian libros de segunda mano. 4. ¿ Se habla inglés allí ? 5. Creo que no, pero se habla francés en todas partes. 6. No se admiten perros. 7. Se suplica el silencio. 8. Se viaja más en la actualidad. 9. El viaje se hacía entonces á caballo. Se tardaban veinte ó treinta días. 10. ¿ Cuanto se tarda de aquí á Barcelona ? 11. Se tardan día y medio por tierra y siete ú ocho días por mar. 12. Se presta dinero. 13. El resultado de la votación no se sabe todavía. 14. Se vende en todas partes. 15. Se gastan dos millones al año en obras públicas. 16. Se continuará la semana que viene. 17. Se desea un taquígrafo español. 18. Se prohibe fumar. 19. ¿ Se cambia dinero español en el hotel ? 20. Creo que sí. 21. Se alquila un piso amueblado. 22. ¿ Como se pronuncia esta palabra ? 23. La última vocal se suprime. 24. Eso solar se vende á bajo precio. 25. ¿ A que hora se servirá la cena ? 26. A las siete en punto. 27. Aquí se despachan billetes. 28. Se cobran alquileres. 29. Se hacen trajes á medida. 30. Se componen baules. 31. Véase la página ciento seis. 32. Solicítese por carta. 33. Pídase la lista de precios.

READING EXERCISE

El Canal de Panamá tendrá seis esclusas dobles : tres pares en Gatun ; un par en Pedro Miguel, con un descenso de treinta pies y un tercio ; y dos pares en Miraflores, con un desnivel combinado de cincuenta y cuatro pies y dos tercios á marca media. Las dimensiones utilizables de todas son iguales : mil pies de largo y ciento diez pies de anchura. Cada esclusa será una cámara cerrada con las paredes y el piso de hormigón y dos compuertas en cada extremo. Las paredes laterales serán de cuarenta y cinco á cincuenta pies de ancho en la base, estrechándose desde los veinticuatro pies y un tercio encima del fondo, hasta tener ocho pies de ancho en su coronación. La pared central tendrá sesenta pies de grueso y ochenta y un pies de altura aproximadamente, y sus dos paramentos serán verticales. A los cuarenta y dos pies y un tercio sobre la superficie del piso y quince sobre el arco de la atarjea central esa pared se dividirá en dos partes, quedando un espacio en el centro, semejante á la letra "U." En este espacio central habrá un túnel dividido en tres pisos ó corredores. La galería más baja servirá para el desagüe ; en la del centro se instalarán los alambres conductores de la corriente eléctrica, que ha de hacer funcionar las compuertas y las válvulas colocadas en el muro central ; la galería alta servirá de pasadizo para los operarios.

TRANSLATION OF READING EXERCISE

The Panama Canal will have six duplicate locks : three pairs at Gatun ; one pair at Pedro Miguel, with a fall of 30⅓ feet : and two pairs at Miraflores, with a combined descent of 54⅔ feet from mean water-level. The working dimensions of all are equal to a 1000 feet in length and 110 feet in width. Each lock will be an enclosed space, with sides and floor of cement, and provided with two flood-gates at each end. The side walls will be 45 to 50 feet thick at the base, narrowing from a point 24⅓ feet above the floor until they are 8 feet thick at the summit. The central wall will be 60 feet thick, approximately 81 feet high, and its two sides will be vertical. At 42⅓ feet above the surface of the floor, and 15 feet above the arch of the central sewer, this wall will be divided into two parts, leaving a space in the centre resembling the letter "U." In this central space there will be a tunnel divided into three storeys or corridors. The lowest gallery will serve as a drain ; in the middle one the wires for conducting the electric current to be used in operating the flood-gates and valves placed in the central wall will be installed ; the upper gallery will be used as a passage-way for the mechanics.

Continued

GERMAN

Continued from page 2495

By P. G. Konody and Dr. Osten

XLII. Strong Verbs. The following strong verbs change the stem-vowel -ei- into -i- or -ie- in the imperfect and past participle. Those verbs which are made prominent in print are conjugated with **ſein**, all others with **haben**.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Conjunctive	Imperative	Past Participle
beflei'ßen	to bestow pains upon a thing, to apply one's self to	ich befleiß-e, -eſt, -t	ich befliß	ich befliſſe	befleiß(e)	befliſſen
beißen	to bite	ich beiß-e, -eſt, -t	ich biß	ich biſſe	beiß	gebiſſen
bleiben	to remain	ich bleib-e, -ſt, -t	ich blieb	ich bliebe	bleib(e)	geblieben
erblei'chen*	to die, to turn pale	ich erbleich-e, -ſt, -t	ich erblich'	ich erbliche	erbleich(e)	erblichen
gedei'hen	to thrive	ich gedeih-e, -ſt, -t	ich gedieh	ich gediehe	gedeih(e)	gediehen
gleichen	to equal	ich gleich-e, -ſt, -t	ich glich	ich gliche	gleich(e)	geglichen
gleiten	to slide, glide	ich gleit-e, -eſt, -et	ich glitt	ich glitte	gleit(e)	geglitten
greifen, ergreifen	to seize, catch, lay hold on	ich greif-e, -ſt, -t	ich griff	ich griffe	greif(e)	gegriffen
kneifen	to pinch	ich kneif-e, -ſt, -t	ich kniff	ich kniffe	kneif(e)	gekniffen
leiden	to suffer	ich leid-e, -eſt, -et	ich litt	ich litte	leide	gelitten
leihen	to lend	ich leih-e, -ſt, -t	ich lieh	ich liehe	leih(e)	geliehen
meiden	to shun	ich meid-e, -eſt, -et	ich mied	ich miede	meide	gemieden
pfeifen	to whistle	ich pfeif-e, -ſt, -t	ich pfiff	ich pfiffe	pfeif(e)	gepfiffen
preiſen	to praise	ich preiſ-e, -eſt, -t	ich pries	ich prieſe	preis(e)	geprieſen
reiben	to rub	ich reib-e, -ſt, -t	ich rieb	ich riebe	reib(e)	gerieben
reißen	to tear	ich reiß-e, -eſt, -t	ich riß	ich riſſe	reiß(e)	geriſſen
reiten†	to ride	ich reit-e, -eſt, -et	ich ritt	ich ritte	reit(e)	geritten
ſcheiden	to depart	ich ſcheid-e, -eſt, -et	ich ſchied	ich ſchiede	ſcheide	geſchieden
ſcheinen	to shine, seem	ich ſchein-e, -ſt, -t	ich ſchien	ich ſchiene	ſchein(e)	geſchienen
ſchleichen	to sneak, crawl	ich ſchleich-e, -ſt, -t	ich ſchlich	ich ſchliche	ſchleich(e)	geſchlichen
ſchleifen‡	to sharpen, grind	ich ſchleif-e, -ſt, -t	ich ſchliff	ich ſchliffe	ſchleif(e)	geſchliffen
ſchneiden	to cut	ich ſchneid-e, -eſt, -et	ich ſchnitt	ich ſchnitte	ſchneid(e)	geſchnitten
ſchreiben	to write	ich ſchreib-e, -ſt, -t	ich ſchrieb	ich ſchriebe	ſchreib(e)	geſchrieben
ſchreien	to shout	ich ſchrei-e, -ſt, -t	ich ſchrie	ich ſchriee	ſchrei(e)	geſchrieen
ſchreiten	to stride	ich ſchreit-e, -eſt, -et	ich ſchritt	ich ſchritte	ſchreit(e)	geſchritten
ſchweigen	to keep silence	ich ſchweig-e, -ſt, -t	ich ſchwieg	ich ſchwiege	ſchweig(e)	geſchwiegen
ſpeien	to spit, vomit	ich ſpei-e, -ſt, -t	ich ſpie	ich ſpiee	ſpei(e)	geſpieen
ſteigen	to rise, mount, ascend	ich ſteig-e, -ſt, -t	ich ſtieg	ich ſtiege	ſteig(e)	geſtiegen
ſtreichen	to stroke	ich ſtreich-e, -ſt, -t	ich ſtrich	ich ſtriche	ſtreich(e)	geſtrichen
ſtreiten	to quarrel	ich ſtreit-e, -eſt, et	ich ſtritt	ich ſtritte	ſtreit(e)	geſtritten
treiben	to drive, press	ich treib-e, -ſt, -t	ich trieb	ich triebe	treib(e)	getrieben
verblei'chen	to fade, to decease	ich verbleich-e, -ſt, -t	ich verblich	ich verbliche	verbleich(e)	verblichen
verzei'hen	to forgive	ich verzeih-e, -ſt, -t	ich verzieh	ich verziehe	verzeih(e)	verziehen
weichen §	to yield, give way	ich weich-e, -ſt, -t	ich wich	ich wiche	weich(e)	gewichen
weiſen	to show, point out	ich weiſ-e, -eſt, -t	ich wies	ich wieſe	weiſe	gewieſen
zeihen	to accuse	ich zeih-e, -ſt, -t	ich zieh	ich ziehe	zeih(e)	geziehen

* To die: strong; to turn pale: weak—examples: er erblich' and er erbleich'te; as transitive bleichen (to bleach) takes weak inflections: er hat die Leinwand gebleicht, he has bleached the linen.

† Reiten is conjugated with ſein and haben; the rules of the alternative conjugations will follow later.

‡ Schleifen in the sense of to trail, to pull along, and to demolish, is weak: der Wagen, die Feſtung wurde geſchleift, the carriage was pulled along, the fortress was pulled down; but: das Meſſer wurde geſchliffen, the knife was sharpened. Schleifen in the sense of "to skate," or "to dance" also takes weak inflections.

§ Erwei'chen, to soften, mollify, touch, is weak.

XLIII. Plural of Compound Nouns. As a rule the last word only of compound nouns takes the plural: der Nacht-Schmetterling (*sing.*) the night-butterfly, die Nacht-Schmetterlinge (*pl.*); das Bauernweib (*sing.*) the peasant-woman, die Bauernweiber (*pl.*). Several compound nouns contain already in the singular words used in the plural: die Töchterschule (*sing.*), the school for girls [daughters]; der Bücherwurm, the bookworm; der Bildersaal, the picture-gallery. The plural of these is formed in the usual way by changing the number of the last word; die Töchterschulen, etc.

1. Several compounds with -Mann (man) form an irregular plural with -Leute (folk, people): der Hauptmann (*sing.*) the captain, die Hauptleute (*pl.*); der Kaufmann (*sing.*) the merchant, die Kaufleute (*pl.*); der Seemann, the sailor, die Seeleute (also die Seemänner), etc. Others form the regular plural with -Männer—examples: der Staatsmann, the statesman, die Staatsmänner; der Gewährsmann, the warranter, surety, guarantee, die Gewährsmänner; der Ehrenmann, the man of honour, die Ehrenmänner, etc.

2. The application of the plural -leute or -männer confers a different meaning to several words belonging to this class: Dienstmänner (*pl.*) messengers, and Dienstleute (*pl.*) servants; Ehemänner (*pl.*) husbands, and Eheleute, husband and wife. The substantive der Bauer, the peasant, forms the regular plural die Bauern, and also the compound plural die Bauersleute, denoting peasants of both sexes.

XLIV. Plural of Nouns of Measure. Substantives of measure, when used after cardinal numbers and in a collective sense, generally retain the form of the singular in the plural: fünfzig Pfund (*sing.*) schwer, fifty pounds [heavy] of weight; zwanzig Stück (*sing.*) Tuch, twenty pieces of cloth; 16 Faust (*sing.*) hoch, 16 ["fists"] hands high; 4 Sack (*sing.*) Kaffee, 4 bags of coffee; 100 Mann (*sing.*) Garde, 100 men of the Guards; fünf Dutzend (*sing.*) Federn, five dozen pens, etc.

1. The nouns of measure of *feminine* gender, ending in an unstressed -e, always form the plural by adding an -n: fünf Flasche-n (*pl.*) Wein, five bottles of wine; zehn Meile-n (*pl.*) weit, ten miles distant; acht Kiste-n Indigo, eight boxes of indigo; 50 Tonne-n (*pl.*) Eisen, 50 tons of iron; die Million (*sing.*) forms the plural die Million-en.

2. Nouns indicating the measure of time always form their plural with an inflection: das Kind ist sechs Jahr-e, drei Monat-e und vier Tag-e alt, the child is six years, three months and four days old.

XLV. Conjunctions. These serve either to co-ordinate or to subordinate clauses or words. In *co-ordination* the joined sentences retain their full independence and their original weight, the structure of the sentences joined by the conjunction remaining unaltered. Conjunctions of this class are:

und, and	dessen un'geachtet, nevertheless
sowohl' . . . . . als, as well . . . . . as	den'noch, yet
aber, but	einerseits . . . anderseits, on the one hand, on the other hand
allein', but, only	
o'der, or	
son'dern, but	darum, deshalb, therefore
nämlich, namely	

Examples: Die Sonne scheint, die Blumen blühen und die Vögel singen, the sun shines, the flowers bloom, and the birds sing, etc.

The *subordinative* conjunctions connect two sentences, one of which is subordinated to the other. The subordinate clause is not complete in itself, and has no sense if detached from the sentence on which it depends. Conjunctions of this class are:

daß, that	ob, whether
so daß, so that	wenngleich, obgleich, although
ohne daß, without	
auf daß, damit, so that	gleichwie, as
als, da, wie, as, than	nachdem, after
inwiefern, insofern, in so far as	bis, till, until
	ehe, bevor, before
während, whilst	weil, because
seit, since	wann, if, when
je nachdem, according to	falls, in case
als ob, as if, as though	etc.

1. The border-line which separates conjunctions, adverbs, and prepositions is not very distinct; adverbs are often used as conjunctions, and conjunctions as prepositions—for instance: während signifies "whilst" and "during." Example: Wir wanderten während der Nacht, we wandered during the night; and der Tag war schön, während die Nacht regnerisch war, the day was fine, whilst the night was rainy.

2. The following interrogative pronouns are classed among the conjunctions if they are used to connect relative or subordinate clauses:

wo, where	wobei, whereat, at which
womit, wherewith	woher, whence
worin, in which, wherein	weshalb, wherefore
	wohin, where to, whithe.
wie, how	wann, when
worauf, whereupon, upon which	warum, why
	weswegen, wherefore

Examples: Dies war es, worin ich bei'stimmte. It was that, to which [whereto] I assented; ich verstand nicht, worauf er an'spielte, I did not understand to what he alluded

3. If the conjunction introduces the subordinate clause the verb must be placed at the end; in compound tenses the auxiliary verb occupies the last place: Er sah mich, ehe ich ihn sah, he saw me before I saw him; and er sah mich, ehe ich ihn gesehen hatte, he saw me before I had seen him; er schlief, als wir kamen, he slept when we came; and er schlief, als wir gekommen waren, he slept when we had come.

4. If the subordinate clause with the conjunction is placed at the beginning of the complex sentence, the verb in the second sentence must *precede* the subject: Ehe er mich sah, ging (verb) ich (subject) fort, before he saw me, I went away; als sie ab'reiste, war (verb) es (subject) schon

dunkel, when she departed, it was already dark. If the same sentences are reversed, subject and verb resume their normal position in the principal sentence: Ich ging fort, ehe er mich sah; es war schon dunkel, als sie abreiste.

EXAMINATION PAPER

1. Which vowels are taken in the imperfect and in the past participle by strong verbs with the stem-vowel -ei-?
2. Under what circumstances do certain verbs in this group form a weak imperfect and past participle, and which are these verbs?
3. Which word of a compound substantive takes the plural, and which remains unchanged?
4. In what circumstances do both words show the plural form?
5. How is the plural of compounds with -mann formed?
6. Which nouns denoting measure do not take the plural, and which form the plural with the usual inflections?
7. Which nouns of measure always take the inflectional -n in the plural?
8. How is the position of the verb influenced by a subordinative conjunction, introducing a subordinate clause?
9. How is the auxiliary verb in compound tenses placed in a subordinate clause introduced by the subordinative conjunction?
10. What rule has to be observed with regard to the position of subject and verb in clauses where the subordinative conjunction is placed at the beginning of the compound sentence?

EXERCISE 1. (*a*) Change the present tense of the verbs in the following sentences into the *imperfect* and *perfect*:

Ich bleibe zu Hause; du pfeifst laut; das Mädchen
I stay at home; you whistle loudly; the girl
reibt die Diele; wir schreiben Briefe; das Kind
scrubs the floor: we write letters; the child
schreit entsetzlich; die Männer schweigen;
is screaming terribly; the men keep silence;
wir steigen auf den Berg; ich verzeihe Ihnen;
we ascend the mountain; I forgive you;
der Hirt treibt das Vieh auf die Weide;
the shepherd turns the cattle out to graze;
der Knabe weist mir den Weg ins Dorf.
the boy shows me the way to the village.

(*b*) Change the imperfect and perfect of the following sentences into the present tense:

Ich biß in den Apfel; weshalb bist du nicht
I bit into the apple; why did you not
bei uns geblieben? Der Künstler ergriff das Instrument;
stay with us? The artist seized the instrument;
wir haben große Schmerzen gelitten; der Kutscher
we have suffered great pain(s); the coachman
pfiff eine Melodie; das Mädchen hat eine Rose
whistled a tune; the girl has pulled a rose
vom Zweige gerissen; die Sonne schien hell;
off the branch: the sun was shining brightly;
der Bettler schlich an der Mauer hin; was haben Sie
the beggar crept along the wall; what have you
mir geschrieben? Der Mann und die Frau
written to me? The man and the woman
stritten heftig.
quarrelled violently.

EXERCISE 2. (*a*) Change the singular of the compound nouns and words agreeing with them in the following sentences into the plural. [The compounds are indicated by the sign =.]

Wo ist mein Tinten=faß (*n.*)? Ich kann nicht
Where is my inkstand? I cannot
meinen Hand=schuh (*m.*) finden. Geben Sie mir mein
find my glove. Give me my
Taschen=tuch (*n.*). Die Messer=klinge (*f.*) ist gebrochen;
handkerchief. The blade of the knife is broken;
die Pfauen=feder (*f.*) ist schön; das Arm=band (*n.*)
the peacock-feather is beautiful; the bracelet
war aus Gold; der Fuß=boden (*n.*) war
was of gold; the floor was
mit Teppichen belegt; das Wein=glas (*n.*) ist leer;
covered with carpets; the wine-glass is empty;
der Gold=schmied (*m.*) hat schöne Ringe.
the goldsmith has beautiful rings.
Aus welchem Stoffe ist Ihre Hals=binde (*f.*)?
Of what material is your necktie?
Geben Sie mir gefälligst das Obst=messer (*n.*).
Pass the fruit-knife, if you please.

(*b*) Change the plural of the compounds and words in agreement with them into the singular:

Die Sing=vögel (*m.*) ziehen im Herbst nach dem
The singing-birds migrate in the autumn to the
Süden; die seidenen Regen=schirme (*m.*) sind nicht sehr
south; the silken umbrellas are not very
haltbar; die Augen=lider (*n.*) sind geschwollen; ich kaufte
durable; the eyelids are swollen; I bought
einige Erd=beeren (*f.*). Wohin führen diese Wald=
some strawberries. Whither lead these forest-
pfade (*m.*)? Ich besitze zwei Winter=röcke (*m.*).
paths? I possess two [winter] overcoats.

(*c*) Form the plural of the compound nouns and words agreeing with them in the following sentences. [Remember the rules concerning the plural of nouns with the indefinite article.]

Der Hauptmann (*m.*) kommandirte die Truppen;
The captain commanded the troops;
ich sandte den Dienstmann nach Hause; ein Kaufmann
I sent the messenger home; a merchant
muß rechnen können; ein Staatsmann sollte
must know how to calculate: a statesman ought
nicht irren; ein junger Ehemann
not to [err] make mistakes; a young husband
ist gewöhnlich nachgiebig.
is generally indulgent.

(*d*) Form the plural of the following nouns of measure, changing the cardinal numeral one into ten:

Ein Pfund Kaffee, ein Bund Stroh,
One pound of coffee, one bundle of straw,
ein Faß Petroleum, ein Buch Papier,
one barrel of petroleum, one quire of paper,
ein Sack Reis, eine Flasche Wein,
one bag of rice, one bottle of wine,
ein Ballen Wolle, eine Tonne Kohle,
one bale of wool, one ton of coal.
eine Woche, eine Stunde, eine Meile,
one week, one hour, one mile,
ein Kubik=Fuß Holz, eine Kiste Zucker.
one cubic foot of timber, one case of sugar.

EXERCISE 3. **Reverse the following subordinate clauses by putting the second clause in the first place (for instance: Er sah mich, ehe er fortging, he saw me before he went away; to be reversed: Ehe er fortging, sah er mich, before he went away, he saw me):**

Wir rauchten, nachdem die Damen sich zurückgezogen hatten;
we smoked after the ladies had retired;
wir gingen fort, weil uns Niemand die Tür öffnete;
we went away because nobody opened the door for us;
er verschwand, ehe ich ihm ein Wort sagen konnte;
he disappeared before I could speak a word to him;
der Weizen wächst, wenn es genügend viel regnet;
the wheat grows if it rains sufficiently;
er frug mich, ob ich zürne; er wünschte
he asked whether I was angry; he wished
abzureisen, falls das Wetter es zuließe;
to depart in case the weather would allow it;
ich schlief, als er kam; sie sang ein Lied,
I slept when he came; she sang a song
da man sie bat, es zu tun; ich gehe nicht fort,
since she was requested to do so; I shall not go
solange Sie es mir nicht zugesagt haben.
until you have promised it to me (literally: I go not away as long as you have not promised it me).

KEYS TO EXERCISES [page 2494]

EXERCISE 1. *Imperfect:* Ich nahm das Geld; der Knabe stahl einen Apfel; was geschah? ich las ein Buch; ihr saht nichts; gaben Sie nichts? du verbargst etwas; wir warfen den Ball; die dame sprach englisch; ich aß Erdbeeren. Er vergaß alles.

Pluperfect: Ich hatte das Geld genommen; der Knabe hatte einen Apfel gestohlen; was war geschehen? ich hatte ein Buch gelesen; ihr hattet nichts gesehen; hatten Sie nichts gegeben? du hattest etwas verborgen; wir hatten den Ball geworfen; die Dame hatte englisch gesprochen; ich hatte Erdbeeren gegessen; er hatte alles vergessen.

EXERCISE 2. Das Lustspiel hat vier Akte; in seinen Träumen hatte er seltsame Gesichte; die Ritter erhoben ihre Schilde; der Richter brachte die Akten; alle hatten bleiche Gesichter; die Schilder über den Ladentüren waren gemalt; wie viele Bände haben Sie? Die Bänder des Hutes sind rot; die Bauer der Vögel waren aus Gold; die Bauern kennen das Wetter.

EXERCISE 3. Wer ist dieser Herr? Was meinen Sie? Wessen Hut ist das? Wem gehört dieses Buch? Wen sahen Sie gestern? Welchem Manne gehört das Boot? Welche Dame kennen Sie? Welche Kinder sollen eingeladen werden? Was für ein glänzender Spieler er ist! Welches schöne Kind sahen Sie? Welch' schönes Kind! Was für Leute sind sie? Was für Getränke bestellten Sie? Was für eine Frau war es?

EXERCISE 4. Diesseits der Mauer, innerhalb des Gartens, stand ein Mann inmitten der Wiese. Zufolge eines Berichtes (or: einem Berichte zufolge) war der Feind geflohen. Trotz meiner Warnungen sprach er mit ihm; um des Himmels willen! Meinem Hause gegenüber wohnt ein Schneider seit einem Jahre; ich öffnete mittelst eines Schlüssels die Türe. Seit Ihrer Abreise sah ich ihn nicht mehr.

Continued

FRENCH

Continued from page 24[illegible]6

By Louis A. Barbé, B.A.

IMPERFECT INDICATIVE TENSE

The endings of the imperfect of the indicative are the same in all verbs. They are *-ais*, *-ais*, *-ait*, *-ions*, *-iez*, *-aient*. This tense is used to express customary or repeated action, and, in narratives, to describe accompanying circumstances, state, or condition:

Autrefois je le rencontrais tous les jours, Formerly I used [to] meet him every day.

Il ventait, il pleuvait, le temps était très rude, The wind [was] blowing, it [was] raining, the weather was very rough.

Un bon feu flambait dans la cheminée, A good fire was blazing in the hearth.

Imperfect Indicative of Avoir:		*Imperfect Indicative of Être:*	
I had, used to have:		I was, used to be:	
j'avais,	*nous avions*	*j'étais*	*nous étions*
tu avais	*vous aviez*	*tu étais*	*vous étiez*
il avait	*ils avaient*	*il était*	*ils étaient*
elle avait	*elles avaient*	*elle était*	*elles étaient*

Imperfect Indicative of Donner:
I used to give, was giving:

je donnais	*il donnait*	*nous donnions*
tu donnais	*elle donnait*	*vous donniez*
ils donnaient	*elles donnaient*	

In expression of time *il y a* is equivalent to the English "ago." It always precedes the words that indicate the length of time:

Il y a dix minutes, Ten minutes ago.
Il y a trois ans, Three years ago.

EXERCISE XIX.

Vocabulary

aile (f.), wing
le bec, beak
le biscuit, biscuit
le bouvreuil, bullfinch
le bruit, noise
la cage, cage
la chambre à coucher, bed-room
le chènevis, hemp-seed
les cheveux (m.), hair
le compagnon, companion
la connaissance, acquaintance
le cou, neck
la croisée, window
le danger, danger
le déjeuner, breakfast
le dos, back
épaule (f.), shoulder
expression (f.), expression
la griffe, claw
l'histoire, (f.), story
l'humeur (f.), temper
intrus (m.), intruder
la journée, day (day-long)
le lendemain, next day
la main, hand
la miette, crumb
le moineau, sparrow
le mois, month
oiseau (m.), bird
le pain, bread
le pas, footstep, pace
le plumage, plumage
la poitrine, breast
la poule, hen
la prison, prison
la provision, stock
le rebord, edge, sill
le rouge-gorge, robin
le secours, help
le séjour, stay

la fin, end
le fumier, heap of manure
le gazouillement, chirp
la gorge, throat
le goût, taste
aimable, kind, kindly
ample, ample
brun, brown
content, pleased
doux, sweet, gentle
dur, hard
entre-baillé, slightly open
épais, thick
gai, cheery
gentil, nice, amiable
la soirée, evening
le son, sound, note
le sucre, sugar
la tête, head
la voix, voice
la vue, sight
hargneux, snappish, surly
heureux, happy
intolérant, intolerant
jaune, yellow
lustré, glossy
moelleux, soft
noir, black
rouge, red
rude, rough
tacheté, spotted, speckled
triste, sad
varié, varied

amuser, to amuse
apporter, to bring
attaquer, to attack
attirer, to attract
becqueter, to peck
caresser, to pet, caress
charmer, to delight
entourer, to surround
éveiller, to waken
fâcher, to anger
filer, to warble, trill
flamber, to blaze
gratter, to scratch, scrape
houspiller, to worry, to mob
inquiéter, to trouble
passer, to spend, pass
rentrer, to come in, return
chasser, to drive off
demander, to ask for
donner, to give
ébouriffer, to rumple, disorder
égayer, to enliven, cheer
enjamber, to step over
saluer, to salute
sauter, to jump
soigner, to tend
tirer, to draw away, rescue
tourner, to turn
trouver, to find
vagabonder, to roam about
voler, to fly
voleter, to flutter

endormi, asleep
entendu, heard
fait, made
mort, dead
ouvert, open
vu, seen

à travers, through
autour de, about, around
bien (before adjectives), very
dehors, outside
ne . . . jamais, never
même, even
pendant que, whilst
presque, almost, nearly
quelquefois, sometimes
souvent, often
trop tard, too late
vite, quickly

Translate into French.

You ask me for the story of my bullfinch; here it is. A friend of mine has a house in the country. I sometimes spend the winter at his house. *I* like the country in winter; *you* like the town better. Each one (to) his taste. Two years ago I (have) made a stay of several months there, and whilst I was there I made the acquaintance of a bullfinch. He was a little bigger than a sparrow; his beak was thick, black, and hard; his little eyes had a kindly expression. I have never seen any plumage more beautiful, more glossy than his. His head was black and his breast almost as red as a robin's. His wings were spotted with (*de*) red also. His voice was sweet, and I have never heard any notes softer and more varied than those which he warbled. He cheered me and delighted me. I tended him, I petted him. When my breakfast was brought me, I gave him his also. I gave him all that he liked most; crumbs of bread, little pieces of biscuit and of sugar. He pecked them in my hand. We were very good friends, he and I. The winter was rough, but that did not trouble us. A good fire blazed in the hearth. We had an ample stock, I, of books, he, of hemp-seed. We were both happy; we were pleased with (*de*) each other. For birds, a cage is often only a prison. *His* was only a bedroom. The door of it was always open. Almost all day long he roamed about through the room. It did not belong more to me than to him. Sometimes he fluttered round me; he jumped on my shoulder, and even on my head; he rumpled my hair. That amused him, and me too. He was a cheery companion. I have never had any nicer than that one. I did not spend all my evenings with him. When I returned I used to find him asleep. He had his head under his wing. The noise of my footsteps used to wake him. He used to salute me with (*par*) a little chirp. Next day I was awakened by my little friend. But the end of my story is something very sad. One day the bullfinch finds the window slightly opened. Whilst I have my back turned, he passes quickly outside. Twenty paces from the house, there is a large heap of manure, yellow and black, where half a dozen hens scratch and peck. It is nothing fine, but it is something interesting for him. From the ledge of the window he flies on to the manure heap. But he is an intruder. The hens have an (the) intolerant and surly temper. The sight of the bullfinch angers them. They surround him, worry him, attack him. The noise attracts me. I look through the window. It is he; it is my poor bullfinch. I step over the window; I go to the help of my little companion. I drive the hens away; I rescue him from their claws. It is too late. My poor little companion is dead.

Key to Exercise XVIII.

1. Où peut-on être mieux qu'au sein de sa famille ?
2. On nous a dit de vous donner ceci.
3. On obéit à ce roi parce qu'on le craint, mais personne ne l'aime.
4. On dit qu'il est très riche.
5. Quiconque a fait cela est un méchant homme.
6. Si quelqu'un vous parle, répondez-lui.
7. Je ne connais personne ici et personne ne me connaît.
8. Si vous avez encore de ces poires, donnez-m'en quelques-unes.
9. Quelqu'un (on) demande à vous parler.
10. Nous avons appris quelque chose de très intéressant.
11. Je connais quelqu'un de plus puissant que lui.
12. Nous n'avons pas fait grand'chose de bon aujourd'hui.
13. Il n'y a rien de plus agréable que de voyager à pied.
14. Y a-t-il rien de plus surprenant que cette histoire ?
15. Chacun de mes amis a remporté plusieurs prix.
16. Faites à autrui ce que vous voudriez que l'on vous fit. 17. J'ai parlé à l'un et à l'autre.
18. Les vrais chrétiens ne médisent pas les uns des autres.

Continued

The Making and Trimming of All Styles of Children's Hats and Bonnets. Dutch and Drawn Silk Bonnets. Polo Caps. Children's Picture Hats.

MILLINERY FOR CHILDREN

How to take measurements and make patterns for children's bonnets has already been treated [page 1846], and we must now proceed to the cutting, making, and trimming.

Three points must be remembered in all children's millinery: simplicity and lightness of style, softness of foundation, and softness of material.

Shape foundations are usually made of domette, leno, book muslin, or stiff net. The materials used are generally swansdown cloth, bengaline, cashmere, corduroy, fine cloths, and Japanese silk.

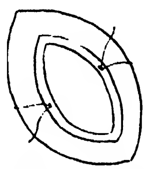
The head-lining should be of sarcenet or mull muslin. The trimmings may be of swansdown, different kinds of white fur, lace, embroidered chiffon, baby ribbon, ruchings, ribbons, quills, tips, appliqués, pompons, etc.

It is best to use washing ribbon for children's bonnets and pelisses. It is made in two widths, 3 in. and 5 in. wide, and is uncrushable and washes well. In appearance it resembles a surah ribbon, and it is made in white and cream.

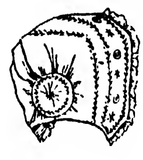
A Baby's Bonnet. A baby's first bonnet can be made in the shape of a hood [157]. Cut two pieces of material the same as pattern, and stitch together round the edge, the right sides inside, cording it between if preferred. Cut away the head part of one to about 3 in. from the edge. Turn it on to the right side, and tack a layer of wadding, domette, or flannel over the single material in the centre. Face this with a piece of sarcenet silk, and run or machine-stitch a sarcenet ribbon on both sides over the cut edges. Mark the centre-front and back, and make an eyelet hole in the ribbon at those places.

Run in China ribbon, secure it at each side, pulling the ribbon front and back to the size of the baby's head. Trim the bonnet with swansdown or lace, and sew on washing ribbon strings, and a cap front, which can be bought ready made or can be very easily made by hand.

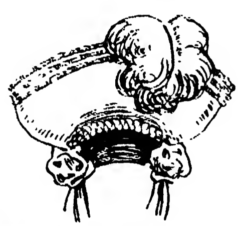
Cap Front. A cap front is made of fine net edged with lace, or lace about 1½ in. wide. Cut two strips of net edged with lace 30 in. long, and pleat it in close boxpleats or quill, making it a little fuller on the top, and catching in the ends. Bind the edge with a strip of firm muslin, 14 in. long when made, the usual length of these cap fronts. This pattern can be enlarged or reduced, and it is made without any wire.



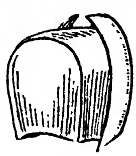
157. BABY'S BONNET



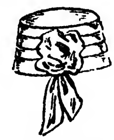
158. VELVET BONNET



159. BOY'S PICTURE HAT



160. DUTCH BONNET



161. POLO CAP

For summer wear, embroidered cambric, muslin, narrow rows of Valenciennes lace sewn together with fancy stitch in silk, or all lace, can be used, left transparent or lined with a thin silk lining of white or coloured silk.

For winter wear [158] the bonnet can be made in velvet, embroidered by hand, or of bengaline silk with fancy stitching, or cloth, and trimmed with fur or lace appliqués. These bonnets can be kept quite plain, with only a silk cord round the edge. Large soft silk rosettes at each ear give a pretty finish becoming to some children's faces. For others the rosette will look better if placed higher. When using washing materials make them up in the same way, but use no stiffening.

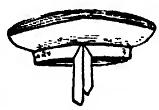
Baby Girl's Bonnet. The materials required for a baby girl's first bonnet are 1 yard of silk, 2½ yards of lace 1 in. wide, 3 yards of insertion, 1½ yards ribbon, and some twist. The bonnet can be made without a shape, with only a narrow band of double muslin ½ in. wide, measuring about 14 in. long (measurement, from ear to ear round front), and 11 in. long from ear to ear round back. This slip will give the required firmness round the edge and help to keep the bonnet in position. Bind the edge with sarcenet ribbon or narrow silk to make it quite neat inside.

For the crown cut a strip of silk 15 in. wide and the width of the silk on the straight. Make three ¼-in.-wide tucks, insert a strip ¾ in. wide of Valenciennes insertion lace, and continue till there are three rows of insertion and four sets of tucks. Gather the edge to size of band round face, and draw up the tucks to shape.

Gather the remaining edge, leaving about 2½ in. at each end, join neatly, and arrange the gathers round a piece of muslin cut in a round about the size of a half-crown. Cover this with silk and trim it. Sew the lower edge to the band, which will form the back of the bonnet.

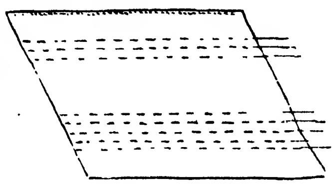
As no head-lining is required, cut another round of silk and slip-stitch it neatly over the

round inside the bonnet, to keep it quite neat inside. Cut a strip of silk on the cross about 6 in. through. Fold this in half and lightly run a ruching of silk or chiffon, or a frill of Valenciennes lace, on the double edge. Mark the centre and slope the ends to 1½ in. Pleat this frill in box-pleats round the front of bonnet, keeping most of the fulness to the top, and finish it off with narrow ruching all round the bonnet. The strings may then be sewn on.



162 MAN-OF-WAR HAT

Baby Boy's Hat. For the foundation of a hat suitable for a baby boy make a band the size of the child's head in double book muslin or net. Cut a circle, 14 in. to 18 in. in diameter, of the material, interlining it, and use sarcenet for head-lining. Gather it round the edge and sew to band. Trim with a ruche of lace or ribbon round band, a rosette, quill, or pompon. Slip-stitch the head-lining round band. Finish with lace cap-front, and strings.



163. SILK FRILLS

These hats can also be made with full crowns, and box-pleated silk or ribbon about 5 in. wide, edged with swansdown, can be used for brim. For trimming, turn up the brim from the face, holding it in place with pompon or rosette.

For older boys white felt hats with dome or square crowns are suitable [159]. Line the brim with gauged silk or chiffon, or only the edge can be trimmed with gauged tucked silk, about 1½ in. wide on either side when finished. Place a ribbon ruche round crown and finish with tips (coming over brim in front, where it is caught to the crown), a rosette of soft silk, strings, and cap-front.

Small polo caps [161] covered in bengaline, and simply trimmed with a large soft silk rosette on one side, are also much worn.

Dutch Bonnet. Little Dutch or Puritan bonnets are suitable for little girls of from two to four years of age [160]. These have generally a coronet, of which there are a great variety of shapes [49, 50, page 1845].

Cut the pattern in buckram, without turnings. Wire round the back part, leaving 1 in. at each side. Wire-stitch the front on to the back, and then wire all round the bonnet, nipping over the 1 in. left at each side and overlapping the wire for 2 in. at the centre-back.

Mull all the edges and wire and mull the coronet, which is covered before it is sewn to the bonnet, in the same way.

Covering the Shape. To cover the shape place the material with the front to the cross, allowing ½ in. turnings all round. Cover the back part of bonnet first, fitting it carefully and sewing the turnings to the front of the bonnet.

Fit the front part, turn in the edge at back, and fit it tightly round the edge of the shape. Catch-stitch the turning on the inside of the buckram in front. Then cut the lining the same shape as pattern, make up and slip-stitch it in the bonnet. Cover the coronet with the material and face it inside with silk. Slip-stitch the edge of the coronet to the edge of bonnet, and make a quilling of lace, chiffon, or ribbon and sew on front.

Trim the coronet with hand embroidery, lace, appliqués, or edge it with fur or kilted ribbon. Another pretty method is to cover the coronet with gathered or gauged silk or chiffon, or with velvet or velveteen, hand embroidered.

Instead of coronets, a very full accordion-pleated silk material, cut on the cross, doubled and lined, and cut narrower at the ears, or gathered or box-pleated, may be made and sewn to the front of bonnet. With a very full front it looks better to have the back fancifully draped or gauged.

Boy's Man-of-War Hat. The only measurement required for a boy's man-of-war hat is the size of the head. Half a yard of double-width material will make two hats. The other materials needed are buckram, 1¼ yards of ribbon, canvas, wadding, ½ yard sarcenet or satin [162].

Cut two circles 10 in. to 12 in. in diameter in material, muslin, and lining.

Make a band 1 in. to 1½ in. wide of buckram or double canvas, or of linen for washing hats, and in length 1 in. longer than head size. Join and wire top and bottom. Mull and cover with material.

Having finished the foundation, place two pieces of material with the right sides facing each other. Take two circles of canvas, each padded with a layer of wadding; tack the head-lining over each circle, and quilt with the machine, each piece in one direction only.

Place one piece of canvas and lining above, and one below. Mark the size of the head-line. Cut out carefully, allowing ½ in. turning beyond the head-line, one piece of lining, one of canvas, and one of material.

Machine-stitch round outer edge, which can be first corded by placing a crossway piece of material with cord tacked in; place this between the two edges of the material, with the turning to the outside, the cord towards the centre. Keep it in a good shape while doing the outside edge.

The band is made of a strip of buckram, 1 in. to 1½ in. wide, and, in length, the size of head, plus 1 in. for turning. Join in a round, and wire top and bottom. Mull and cover with cloth. Sew the crown to band, and line the band neatly, or machine carefully just above and below the wire of band.

Trim the hat with the ribbon, which usually has the name of a man-of-war stamped on in gilt letters.

A washable man-of-war hat is made in the same way. White drill, piqué, or bengaline is used, and white canvas or linen used for interlining. The band should not be wired, but made of double canvas, covered with drill, cut twice

the width of the band, plus ½-in. turnings. Place the canvas between, tack and turn in the ½-in. turning. Place the crown between, tack and machine-stitch crown to band.

In bengaline or any other white material which can be dry-cleaned, the band may be made as in the first method described.

Girls' Liberty Hats. Liberty hats are made of Liberty or Japanese silk. A fair-sized hat, with frills at edge, will take from 2½ yd. of 36-in.-wide silk. They are exceedingly pretty made in white for young girls' wear. For adults, these gathered and drawn hats can be made in net, plain or spotted, chiffon, and in a variety of other materials.

They take 2½ yd. to 3½ yd. of 36.-in.-wide silk, a ring of strong white support wire, and one reel of strong machine silk (the ¼-oz. reels are the best), buckram for head-band, stiff muslin or net for the crown, and sarcenet for the head-lining.

The measurements required are the size round head, and, if possible, the diameter of a large hat that suits the girl for whom it is intended.

The width of the brim will be according to the size of the head—the larger the head-line, the wider the brim.

The silk may be cut on the cross or straight. The first is better when frills are required at the edge, the latter when more than one hat is to be cut from one length of silk. Silk on the straight is also easier to manipulate and join. The length will be two and a half times the circumference of hat.

To allow of its being made up double, cut the silk twice the width of the brim. Allow ½ in. extra for each tuck, and double the width of each frill at the edge. Join it in a round and press all the seams *in one direction*. Mark the half and quarters. Fold in half and tack the raw edges together

Mark with lillikins the width of frill, 1 in. to 2 in. round edge. If a double frill is required at the edge, pin and tack. Mark ¼ in. away from first marking—this will be for the first casing.

The space between the two lines of running must be just wide enough to allow the wire to pass through double at its end [163]. If made wider, the gatherings will not look well when drawn up. If made narrower, the wire doubled at the end will not pass through, and it will give a great deal of trouble to finish off. Mark the remainder of brim, leaving 1 in. to 1½ in. plain between each casing. The last casing must be about 1 in. from head-line. Thread the needle with strong machine silk, using it from the reel, as it is less likely to get knotted or broken, and fly-run the whole length, beginning from the back. Pull the silk out to its full length before cutting the twist. Fly-run the other casings in the same way.

Wiring the Brim. To wire the brim, cut off the wire for head-line, plus 2 in. for wrapping. Allow plenty of wire for each casing, and 10 in. extra in length for each 1-in. space left between the casings. Bend round the wire ½ in. at end, and bind it with cotton to prevent the silk filament from slipping. Then, from the back, make a little cut in the silk, or undo a few stitches in the seam. Push in for a few inches each wire as it is cut off, to prevent the different lengths from getting mixed. Push in the wires, *all at the same time*, in the direction the seams have been pressed.

Join the head-wire first, overlapping the wire for 2 in. Stitch through the silk and loop of wire on the under side of brim with strong cotton. Draw some fulness over the wire before joining. Draw up each wire in turn, and stretch the silk quite tight between the wires. Draw up the twist on each side of the wire and fasten off.

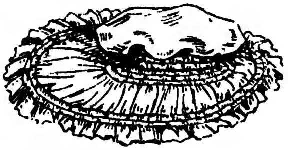
For a brim narrower at the back than at the front [164], make a paper pattern with the brim 1 in. to 2 in. narrower at back, graduating the runners from front to back.

Crowns for these brims are generally low and full on a tam-o'-shanter foundation. Make a head-band and pleat a net or leno crown to it of about 14 in. diameter.

For a large tam-o'-shanter crown, a round, cut the same size as brim, including frills, will make the silk for crown in proportion to the brim. This can be left plain, or embroidered, or trimmed, as preferred. Turn it in and gather round the bottom three times and sew to side-bands. This can be tucked, but the material must be tucked before cutting the circle.

Trimming. Make a large bow across the front, of silk, machine-stitched or slip-stitched, or rosettes, one under and one on top of brim. Young children wear strings of chiffon or silk cut on the straight.

Hats can be made in velvet in the same way, allowing a little less for fulness, to keep them light. Velvet hats made over a sparterie shape, with gauged lining, trimmings, and strings of chiffon, make becoming children's hats.



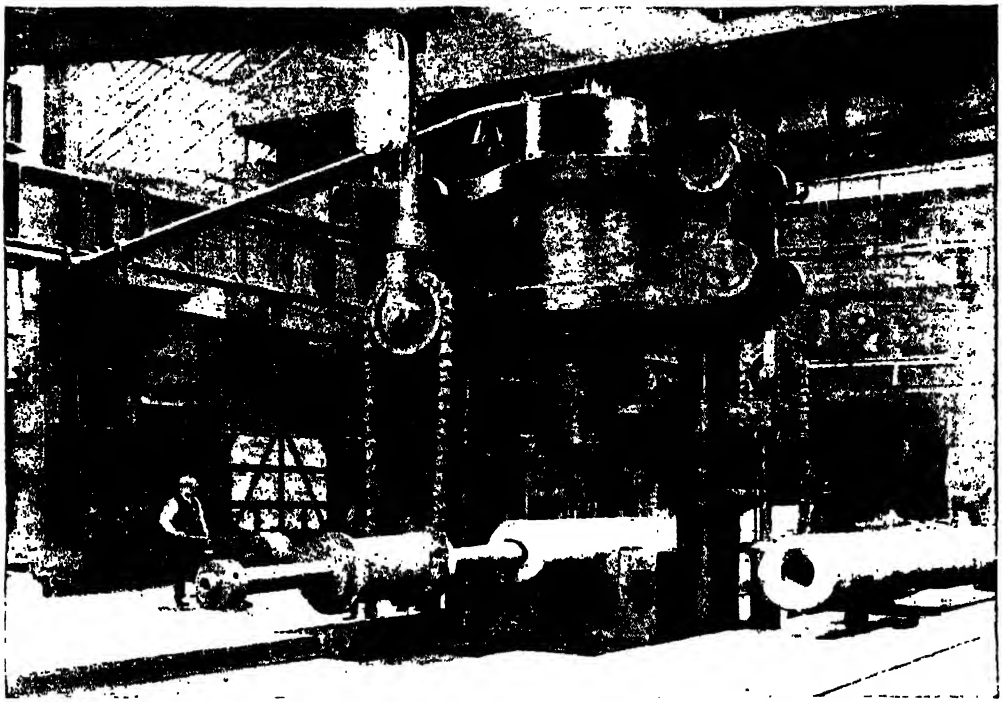
164. GIRL'S SILK HAT

Drawn hats in glacé, taffeta silk, or net are most effective made with raised casings. For these, cut three lengths on the cross, 3½ in. wide. Join and machine-stitch one edge, making a narrow hem. Valenciennes or imitation Maltese lace, about 1 in. wide, can be stitched on at the same time. This is for the frill. Cut three strips 9 in. through on the cross. Join, and press the seams all one way. Make a narrow hem on one side and machine-stitch it. Make a tuck 2½ in. from the edge that has been machine-stitched. Then make three more tucks, leaving 1 in. between.

Push the wire into the tucks, fasten securely in the same manner as for a drawn hat, and pull up the twist. Make the head-band and crown. Halve and quarter the 3½-in. strip of silk ; gather and sew on near the first tuck at the edge to make a double frill there.

Line with gauged chiffon, leaving a heading of about 1½ in. Trim with chiffon strings.

TWO PROCESSES IN BUILDING A BIG GUN



The building of a big gun is a highly complicated proceeding. This picture shows the inner tube being pressed into shape. The tube is wound with miles of steel tape, and is then fitted with an outer jacket.

The outer jacket of a big gun being forged in a hydraulic press. The jacket is thrust over the wire-wound inner tube. The breech end of the jacket is shown on the right-hand of the picture.

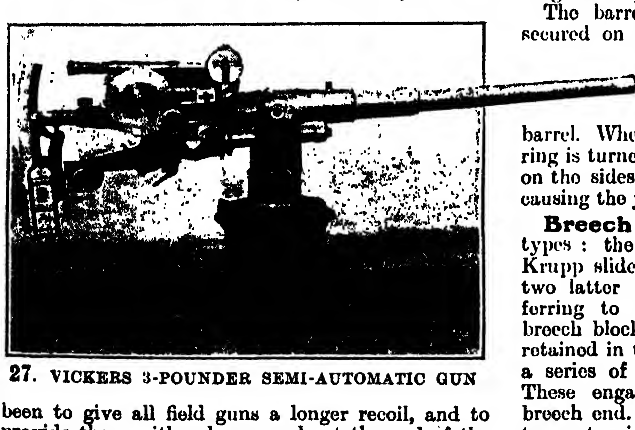
Construction and Manufacture of Large Guns. Making and Charging Cartridges. Shells. Percussion and Time Fuses.

LARGE GUNS AND AMMUNITION

STRIPPED of all accessories, a gun is a thick tube reinforced in those parts where internal pressure is to be expected. The designing of a gun necessitates the use of much complicated mathematics in order that the pressure shall be adequately borne in every part without undue weight. The methods of reinforcement and pressure distribution vary in different practice, but in the British Service the shrinking on of tube over tube is now confined to small weapons. The larger weapons are wire-wound.

Small Calibre Q.-F. Breech-loading Guns. This type [26] is built up from steel forgings and an inner tube with jacket shrunk on them. The inner or "A" tube forging is first rough turned and drilled, simultaneously from both ends, the tube revolving. After this it is tempered and annealed and tested, then opened out to a larger diameter, with a D-shaped boring tool working from the muzzle end, and then fine bored with a built-up boring tool, with several inserted cutters with burnishers between them. Then the rifling operation takes place, the tool used being somewhat similar to that described under Rifle Manufacture.

Jacket. The jacket is next tempered and annealed, and then drilled through, and second bored and second turned. The trunnions are grunched down out of the rough forging, by vertical tools, a number of cutting tools in a bell chuck. But in field guns the tendency of later years has been to give all field guns a longer recoil, and to provide them with a large spade at the end of the trail. This design has caused radical difference in the manufacture of the gun jacket. Figure 27 is a Vickers 3-in. gun and 28 is an Armstrong-Whitworth 3-in. gun. The trunnions are done away with on the jacket, and a slide or grooved way extends the whole length of the gun. Thus, practically, no portion of the outside from breech to the muzzle can now be turned in the lathe, but has to be planed longitudinally, the gun being supported and partially revolved, and the tool box arranged to copy a template fixed upon the machine.



27. VICKERS 3-POUNDER SEMI-AUTOMATIC GUN

The breech is then slotted out in a slotting machine (when of the Hotchkiss or Vickers wedge-breech type), the rear face faced, and the hole flared out to give easy insertion to the shell cartridge. The action holes are drilled through jigs, and a dummy mechanism fitted, to test accuracy; also backsight holes bored. Next the jacket is fine bored to a somewhat smaller diameter than the barrel or "A" tube, and this is called a shrinkage allowance. In several cases there is a locking ring with bayonet joint which is duly machined.

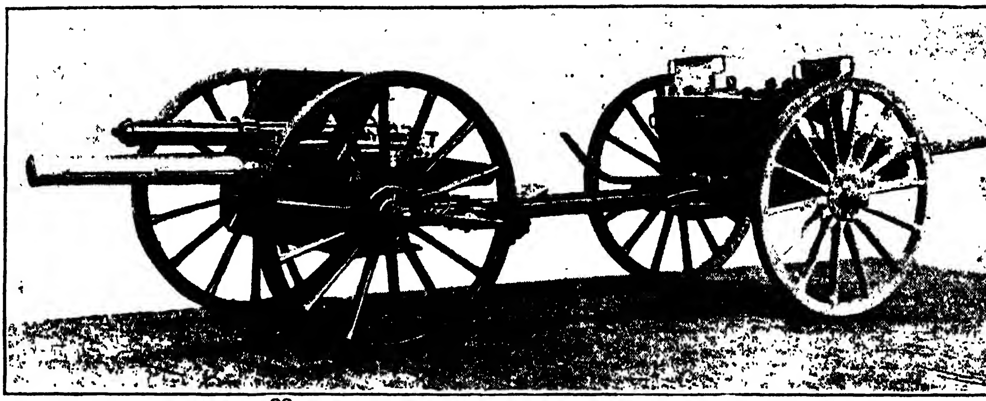
26. VICKERS 3-IN. FIELD GUN

The gun is then ready to be shrunk up. For these small guns, a gas-fired furnace of simple construction may be used. The jacket is fixed on a revolving table perfectly upright, and gradually turned round, to get an equal distribution of the heating.

The barrel, having been already lowered, and secured on to a plate, into the bottom of a pit alongside, has a taper plug placed in the muzzle to form a lead, and to give protection. The jacket is then carefully lowered vertically on to the barrel. When it is home to the shoulder the locking ring is turned, and the key inserted, the key fitting on the sides only. The water jets are turned on, causing the jacket to grip firmly.

Breech Blocks. These are of three principal types: the vertical wedge, A; the transverse Krupp slide, B; and the screwed breech, C—the two latter being now in most general use. Referring to detail of manufacture of "A," the breech block is of the vertical sliding type, and is retained in the breech end of the gun by means of a series of serrated projecting guides, milled in. These engage in corresponding grooves in the breech end. The block is machined with a slight taper, to give it a slight forward movement when closing the breech. The top of the block is milled to a hollow curve to clear the cartridge case in the loading position, and the front is bevelled to press the latter home in closing the breech—the forward movement of the block completing this operation. The front portion of the block is stepped to form a shoulder for actuating the extractor.

The upper portion of the block in line with the centre of the gun is bored out to receive the bush.



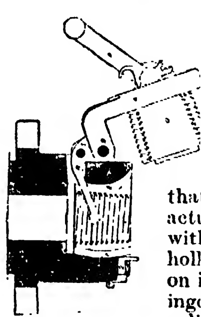
28. ARMSTRONG-WHITWORTH 3-IN. FIELD GUN

for the striker, the former having been previously machined and hardened. This is screwed into the front face to admit the firing pin. At the rear end is provided a sliding cover, a stop pin being provided to limit the opening movement. The striker opening near to the cover is recessed at the top to allow the striker to be removed when the mechanism is assembled. The centre of the lower portion is hollowed out and drilled and end-milled to take the cocking lever, trigger, and mainspring. A wibbled-out slot between this space and the striker opening admits the cocking lever to the latter. Transverse holes are drilled in the lower portion of the block to receive the axis pins for the trigger and cocking lever. The other components, such as the cranks, crank shaft, and sleeve, are machined from steel forgings and hardened.

Semi - automatic and Screwed Breech Blocks. In the semi-automatic type there is also a steel spring of the clock type fixed in a machined-out bronze cover. The extractor, when machined, is pivoted on a hinge pin screwed into the breech of the gun. A cylindrical striker with detachable point and a key is fitted into it. A hole is drilled through the striker for the head of the cocking lever. The cocking lever is forged bell-crank form, and pivoted on an axis pin in the space in the centre of the breech block.

In the Krupp type the breech consists of a transverse slide block with a circular hole through it registering to the chamber when open, but presenting a solid surface when moved across to the closed position.

Referring to the screwed-breech type, there are numerous types of this class. Taking one simple type [29], the screw, which has interruptions (or gaps between), is swung round on a carrier arm, which also has a bevel gear to rotate the screw, so that its threads, which have entered the somewhat radial gaps in the breech screw of the gun, are now threaded, so that they enter and lock into the threads of the gun screw. In this particular type the threads are cut all round and then shaped off to form two interruptions. But a much superior screw breech—namely, the "Welin" type, which has been much improved by Messrs. Vickers—is used for the larger guns.



29. SIMPLE SCREWED BREECH BLOCK

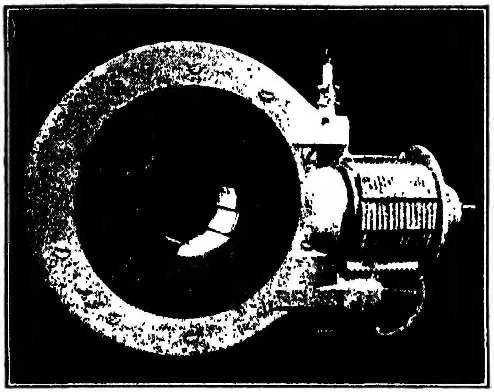
Welin Breech Blocks. This type [31 and 32] gives a much larger thread contact, and therefore support, and for the same reason it is enabled to be shortened, and the gun breech does not need to be radiused for the plug to be swung out. This arrangement of a short plug also enables a very considerable saving in weight to be made in the gun itself at its heaviest portion—namely, the breech end.

The contact area gives as much as 75 per cent. of the circumference as useful support. The thread is of the step-up type. Each segment has a different radius. This would appear to be a very difficult piece of machine work, but the result has been obtained by an ingenious arrangement brought out by Mr. Douglas Vickers. The interruptions, or gaps, are first milled through longitudinally, also narrow tool clearances between the threaded segments. It is then turned, and afterwards screw cut in a lathe, which has an attachment to the cross slide of the saddle, acuated by a cam and strong spring. This enables the tool to snap back quickly to meet the advancing larger radius during the period of passing the clearance groove.

In machining some of the smaller breech plugs, instead of using a forging for each plug, the screw is cut from end to end on a forged bar and then parted off into a number of breech screws, thus saving cost and material. Further, fewer test pieces are required.

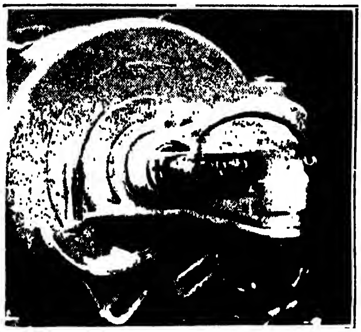
Large Guns. The steel ingots are cast with a large head to ensure soundness. This is cut off in a face-plate lathe by a square, revolving frame, with cutters that are moved forward by transverse screws actuated by a star wheel feed coming in contact with a fixed pin. They are trepanned out by a hollow, annular boring tool with cutting tools on its front face. This, on being fed into the ingot, takes out the centre, thus saving a large cylinder of metal. The ingot is then taken to the large hydraulic forging press and swaged out on a mandrel. Special mechanically-moved turning gear slung from the crane overhead is used. The hollow forgings are then rough bored out from both ends with D-shaped bits, with tooth-shaped cutting edges well supported and backed off to give clearance to the turnings, a copious supply of soapy water under high pressure being carried up to the cutting edges of the tool. They are then rough turned, and taken out to be oil-hardened or toughened and annealed.

The oil-hardening plant is of gigantic dimensions, consisting of high gas-fired furnaces, with firebrick



30. VICKERS 12-IN. BREECH MECHANISM (OPEN)

linings and with hinged front-door opening outwards all the way up, and a table at the base revolved from below by worm gear. Above this, and spanning over the furnaces and oil-tanks, is a 100-ton goliath crane worked by hydraulic power. The oil-tanks are large enough for 16-in. guns, and contain some 15,000 gallons of rape oil. They are partially sunk in the ground, and water is circulated round the annular chamber surrounding the inside shell of the tank, to keep the oil at a fairly equal temperature, and to prevent its firing. The tube is heated to about 1,500° F., and soaked at this heat for some time. Further, to ensure equable heating, it is revolved on the table before mentioned. The top doors are then opened, and the clips put on the tube, which is then lifted by the overhead crane, and plunged into the oil-tank. When ready, it is then taken out and replaced in the re-heating furnace for some time and maintained at a temperature of 700°F. to anneal it. Afterwards it is slowly cooled, and a further tensile test is taken. If correct, it is then taken to the boring lathe and second and fine-bored, and also lapped out. The various jackets and hoops are treated in a similar manner, an allowance being made for shrinkage.



31. 6-IN. BREECH MECHANISM (CLOSED)

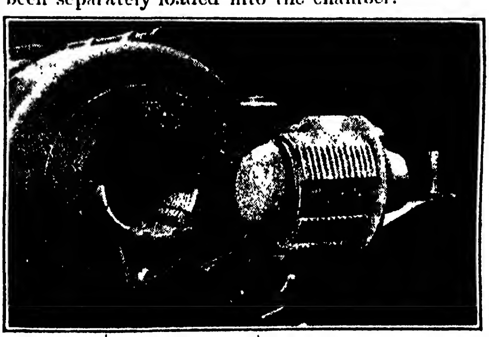
Wire-winding. As the larger guns are wire-wound, they differ somewhat in construction. There is an inner tube, which is second-bored inside, but finished turned outside, and over this is placed the "A" tube proper, and on to this is wound, in the case of the 12-in. gun, some hundred miles of steel ribbon wire under great tension. This winding on tension is regulated by grippers, held towards each other by weighted levers. The weights of these are adjustable in order that the tension may be increased or diminished, as required by theoretical construction. The gun revolves winding on the ribbon in advancing steps or layers. The reel and apparatus traverse the bed longitudinally by a long feed-screw worked by hand. The wire is driven home by a workman with a copper drift, who also carefully examines the wire in transit and *in situ* to detect any defect.

When completely wound, should there be any rough edges on the wire or on the clamp rings, they are trued up in the lathe by spring cutting tools, or, in other cases, ground by emery wheels. Then the jacket and chase hoops which have previously been fine-bored, with a small shrinkage allowance to suit, and also finished turned, are dropped over, and shrunk on. The somewhat contracted bore is finished inside by lapping out. It is also chambered by a built-up broaching-out tool, or, in some cases, bobbed out by an emery wheel on a former. It is now inspected and measured up carefully in the bore, a micrometer gauge being used which registers the dimensions on a dial outside the muzzle end. It is then rifled in a tangent bar rifling machine somewhat similar to that described in our consideration of rifles.

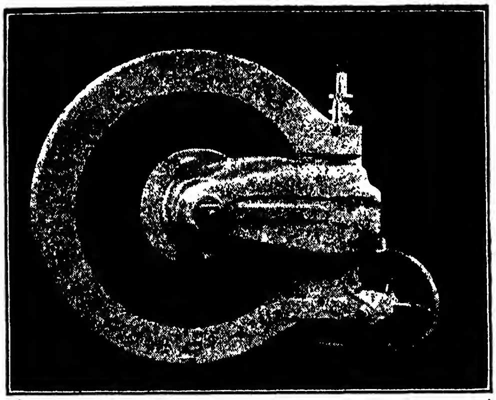
In the meantime, the breech bush has been machined. To make this, an ingot is trepanned and hollow forged under the press in a length suitable for making twenty bushes. It is then rough-turned and bored, and hardened in a similar manner to a gun tube. It is now parted off into lengths and a thread is cut on the outside, and, further, the interior has the interruptions and stepped segments cut into it by special machinery.

When the gun has been rifled and lapped out, the breech bush is screwed in and fixed. The gun is again inspected minutely; to do this in the interior, electric lamps and mirrors are used to detect any defect. Also, internal impressions are taken by wedging inside plastic gutta-percha, which clearly reproduces any roughness or irregularity, and can be examined at leisure when withdrawn.

Obturator. In the case of large calibre guns, no metallic cartridge cases are used, but the efflux of the gases is prevented by the obturating pad. This consists of a plastic pad of asbestos with an unguent kneaded thoroughly into it. This mixture is formed into a pad between dies, under intense pressure, and covered with canvas. When in the gun, the pad is contained between front and rear metallic discs, but is free to expand at the circumference. On firing, the pressure forces back the front mushroom plunger. This compresses the pad longitudinally, and forces it outwards against the chamber, to make a gas-tight joint. The plunger has a hole drilled through its centre, in order that the flash from the primer may communicate with the charge. This charge lies in rear of the shot, each having been separately loaded into the chamber.



6-IN. BREECH MECHANISM (OPEN)



33. VICKERS 12-IN. BREECH MECHANISM (CLOSED)

The breech mechanism is now mounted [30 and 33]. The mechanism is arranged so that, by turning the hand wheel, the breech plug is first rotated and unlocked, then drawn out longitudinally. The obturating pad being now clear, the whole is swung out from the breech of the gun. These motions are obtained by means of a pinion and actuating lever, which rotate the breech plug with gradually increasing rapidity, unlocking it. By a combination of the sliding bar and roller stud, a sleeve is turned, causing the plug to have a longitudinal rear motion. On this movement being continued, the actuating arm swings out the mechanism clear of the gun.

In Vickers' latest type the breech screw is arranged so that, after it has been rotated sufficiently to disengage it from the breech opening of the gun, it is swung directly out toward the operator without any longitudinal withdrawal. This not only reduces the time required to operate the mechanism, but allows the actuating gear to be of the simplest type. Much ingenuity has been expended on the provision of means to prevent the backward rush of flame and fumes when the breech is quickly opened. This is most simply accompli hed by an automatic air blast.

Proof of Guns. After the final inspection of the guns as regards machining, they have to be tested by proof charges at a suitable range. The range, if required for large size of guns, must be in an isolated position near the sea, and should have a railway siding right on to the mounting ground, so that the largest ordnance can be conveyed there. To try the guns, they are mounted on heavy, cast-iron surface plates, anchored down to massive concrete bed. Usually an overhead gantry crane of 50 tons capacity spans the railway siding, so that the heaviest ordnance can be mounted with facility. The targets for armour-plate trials are usually erected some distance away, against a huge bank of sand, while fixed targets are erected on piles some thousand yards to seaward, and floating targets can be moored at any practical range from the shore.

Chronograph. To measure the velocity of the shot an instrument called the *chronograph* is used. This is a time measurer, and is used to record the time taken by a shot traversing from the muzzle of the gun to a point some distance ahead. Two electromagnets are supported vertically. When the circuits are complete they are magnetised, and each one sustains a steel rod. Over it is fitted a silver sleeve to take the knife impressions. One rod is called the *chronometer*, and is a long one; the other is shorter, and is called the *register*. On the register falling, it causes a knife-blade to indent the falling chronometer rod. Forming part of the circuit to the magnet holding up the chronometer rod is a fine copper-wire stretched across the muzzle of the gun, while a certain distance ahead, directly in the path of the slot, there is placed a screen of fine copper wires laced across, and insulated from the screen. This wire forms part of the register circuit. Further, a switch is arranged that can break both circuits simultaneously, called the *disjunctor*. When this is thrown over, both rods are released at the same time, and a mark is indented on the chronometer rod. On firing, the shot breaks the first circuit, causing the chronometer rod to fall, and the shot in passing through the screen breaks the second circuit, causing the register rod to fall. The mark now made is measured to that made by the disjunctor simultaneous release, and the average velocity is obtained therefrom.

Field Carriage. The trunnion and axle bearings of a field carriage [34] are in one forging, and are riveted on to the trail by ample flanges. The traversing plate which supports the cradle is a steel casting. It has two trunnions, which stand out horizontally upon it. These are turned on the journal part on the collar. By means of these trunnions the gun is elevated or depressed. The trunnions lie in bearings in the trail, and are kept in place by cap-squares. The boring bar is passed through the bearings to true them up with the trail. The recesses are slotted out, and the cap-squares fit in sideways. A socket is formed in the traversing plate, in which the traversing pivot rests, and around which the gun is traversed. This traversing pivot is provided with horizontal bearings (for the ranging drums) round which the gun and cradle can be elevated.

The traversing plate extends to the rear in two arms with a cross member to form a bearing for the traversing segment. The latter is machined to radius, and carries the ranging gear. The elevating gear is telescopic, and is arranged for independent or for simultaneous elevation of the gun and sight. The separate and independent elevation are placed one on the left and one on the right side of the carriage. The one on the left elevates the whole system of the gun, cradle and sights, and is used for pointing. The gear on the right-hand side is for ranging the gun, and does not influence the sight. An indicator shows the range of the gun corresponding to the elevating with degrees with line of sight. A hand wheel is on the right-hand side, with a spindle and worm upon it.

34. VICKERS 75-MM. FIELD GUN AND CARRIAGE

This gears into a segment of a worm wheel, to give some degree of traverse in either direction.

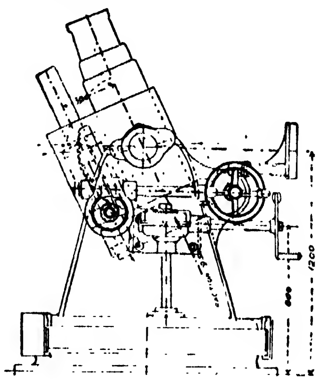
The Cradle and Cylinders. These are made of manganese bronze, and contain the recoil arrangement and running-out springs. A lug is formed on the under side. These are difficult castings to make, owing to the thin walls and long slides causing contraction difficulties, but this has been skilfully overcome by careful moulding. The long grooves on each side of the castings are planed out on a special machine, and, using these as guides, are slid on to fixture, and then the two spring-cases are bored out, and also the recoil cylinder. It will, of course, be seen that the slots retain the gun vertically and laterally.

In the recoil cylinder a liner is forced in with an orifice which controls the flow of the liquid past the piston, through a gradually closing port. The spring-cases that are on each side of the recoil cylinder each contain two springs, enclosed one within the other, but separated by a tubular casing having a rim on the inside at one end, and at outside on the other. As these springs must have approximately equal range and strength, it will be obvious, having in view the different diameters, that the section and pitch of the coils must be carefully calculated to obtain a satisfactory result. The inner spring bears against the enlarged end of a rod, which, after passing through the spring, is securely attached to the lug under the gun, and at the other end it pulls on the inside rim of the tubular case, enclosing this spring, while the outer spring bears against the outside rim of the tubular case; its rear end presses against the cradle itself. By this telescopic arrangement the compression of each spring is about half the distance travelled by the gun in recoiling. A large initial compression has to be given to these springs by screwing up. Suitable wheel brakes are attached.

The bullet-proof shield is bent so that a horizontal portion forms the seat, the rear vertical portion the back, while the front is continued down below the axle, thus screening the men well, and at the same time forming a seat when limbered up for travelling. To protect the gun-layer in these long recoil guns, a protecting shield is fixed at the rear end of the cradle.

In field equipment there are three limbers. The carriage-limber, as shown in **28**, travels with the gun; also the carriage and ammunition limber, which are coupled up and travel together.

The body is made of bullet-proof steel, and contains a number of pigeon-holes, into which are inserted and tightly fitted baskets to contain the made-up rounds. These baskets have a wicker cover with a strap fastening. The end door has to fit up very tightly against these covers, and is padded with felt and leather. In the under-frame corrugated and flanged plates are used, which at once give strength and lightness. The limber hook is made of a steel forging, into which is welded a wearing-strip of special high-grade steel. The pole is made of straight-grained ash, well seasoned and free from defects. The axles are tubular steel, with collars formed upon them. The arms are swaged down, turned in, and welded at the ends. These arms have the necessary "hollow" and "lead," the one to suit the dish of the wheels and the other to ensure straight running on the conical arm. The arms are slotted through to receive a linch-pin, which retains the wheel in place.

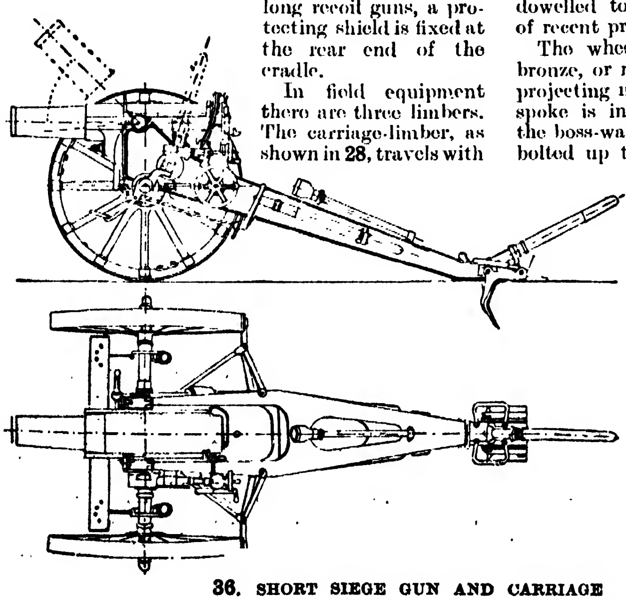


35. HOWITZER

Wheels. The spokes are of cleft oak, well seasoned and selected. They are turned in a coping lathe, and the nave ends are carefully tapered. The spokes are shouldered down to a round section where they fit into the felloes. The felloes are in some cases sawn out of ash, with the grain running round the circumference. They are bored for the end of the spokes to fit into, and are dowelled together at the joints. In other cases of recent practice they are made of bent ash.

The wheel-boss flanges are sometimes cast in bronze, or malleable iron, or of pressed steel, with projecting mid-feathers into which the nave of the spoke is inserted. Outside and socketing on to the boss-washer is the outside disc-washer, which is bolted up to it. Before insertion, the nave ends of the spokes are well coated with white lead paint. The felloes are driven on to the spokes and the spoke ends wedged. Then the welded tyre is placed over this, and in modern practice the shrinking on is done by means of a series of hydraulic rams all round the circumference and acting radially inward simultaneously. Inside the socket of the boss-washer a pipe-box is inserted to form a bearing. Some of the European nations use forged iron or steel wheels for field gun carriages.

Siege Guns and Howitzers. The tendency since the Boer and Japanese wars is to use a siege gun [**36**] with high velocity, and consequently a longer gun, for field service; therefore the weight has to be kept down. For plunging fire, howitzers [**35**

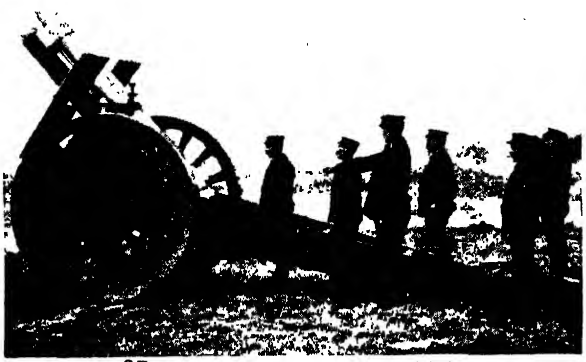


36. SHORT SIEGE GUN AND CARRIAGE

and 37] with high-angle fire are used for field, siege, and garrison purposes.

Aerial Defence Guns. The most urgent problem of the modern artillerist is the provision of means of defence against attack from the air. The really complicated problems brought about by the perfecting of the airship and the aeroplane have been vigorously tackled by Germany, France, and our own War Office, with the result that more or less effective weapons are now available. It is necessary that a gun for air defence should be capable of elevation to nearly a vertical position, and that it should be capable of being trained and sighted very rapidly. An aircraft can alter its position very quickly in any direction, and measures have to be provided to allow for this new problem in fire. For ordinary land or sea-service the movements of the target can only take place in close proximity to the horizontal plane; no plane of movement is outside the capability of the aircraft.

In Krupp's pattern [38] the range and elevation are read off a special range-finder, and the telescopic sight is set to the required elevation. The gun can be moved quickly to follow its flying target, and is mounted on a special type of carriage. Shells which leave a smoke-track are frequently used to trace the path of the projectile and show the cause of a miss, but the question of the kind of shell to be used is not yet satisfactorily settled. Shrapnel suggests itself at once, and flaming and gas-producing shells are also being experimented with.



37. A VICKERS 6-INCH HOWITZER

Mountings. These features cover a multitude of designs—for instance, naval mountings, field carriages and limbers, howitzers, fortress artillery, and barbette mountings. It is impossible to go fully into the manufacture of all these, so the 4-in. pedestal mounting [39] is given in detail, and the others are lightly touched upon. This mounting consists of the following principal parts—namely, pedestal, pivot and carriage, cradle, and shield.

The Pedestal. The pedestal is of forged steel, being flanged at the bottom, and is secured to the deck of the ship with bolts. It is bored and bushed to receive the pivot stem of the carriage, and has at its base a horizontal ball bearing, on which the whole training mass revolves. The top of the pedestal is bored out to receive the training worm wheel, the lower part of which forms a bush, this latter fitting closely to the pivot stem of the carriage. The upper part of the wheel has teeth cut in it for the training worm to gear into, and is provided with a circular facing for resting on the top of the pedestal. The clamping gear is fitted for controlling the mounting, and consists of a friction block, set screw, two Belleville washers, clamping screw, clamping handle, and two stop studs.

Pivot and Carriage. The carriage is a steel forging of two side cheeks and a bottom, with the pivot projecting down. The pivot is a solid steel forging. It is faced on four sides in the planer, then two holes are drilled through it, and the metal of the centre portion is taken out by saws, meeting the drill clearance holes. It is then finished slotted inside. Recesses are formed on the inside on the cheeks for the reception of trunnion blocks, and are constructed so that the gun may be drawn inboard after the blocks are unlocked, without any lifting. The trunnion blocks are forged steel, and provided with locking blocks operated by links and rocking lever on the toggle joint principle. Suitable handles are provided for operating the links and locking blocks, so that the latter may be moved in order to engage with the recesses in the carriage when locked. One block moves upwards, and one downwards into oval recesses in the cheeks in the pivot. On each side of the carriage is bolted a steel side-bar, the left-hand one carrying the elevating and training gear and platform, the right-hand one carrying the training gear and platform.

The Cradle and Recoil Cylinder. The cradle is made of steel plate, and is shaped to take the gun. It also carries the recoil cylinder, spring cases, sighting gear, guard plates, reserve oil-tank, and cover plates. Bronze bearing strips, running circumferentially, are provided at front and rear end of the cradle, on which the gun slides, and at the trunnion end a cap of forged steel, also having manganese bronze bearing strips, is bolted to the cradle. Two key-ways, running longitudinally, and bushes with bronze are provided, one in the cap and one in the bottom of the cradle, forming guides for the keys on the gun.

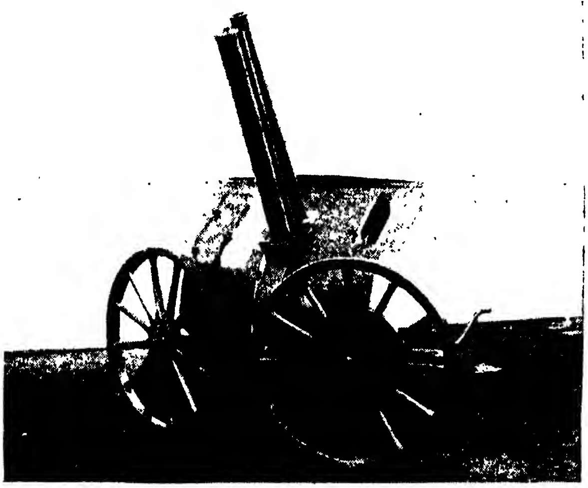
The recoil cylinder is of forged steel and bored out. There is a key on the cylinder, fitted into a recess on the under side of the cradle, to assist in taking the strain when the gun is fired. At the front end of the recoil cylinder is fixed a steel nut, gland, and plug, and into the last is screwed a retarding ram. The rear end is threaded for the cylinder plug, which is fitted with glands and packing, through which the piston rod works. On the top of the cylinder, on the right, is a filling hole communicating with the oil-tank, and in the rear is an oil-hole closed by a plug and leather washer.

The piston and piston rod are in one piece, and of forged steel machined all over, the piston having a circumferential groove turned out, into which is fitted a manganese bronze ring, which fits accurately into the recoil cylinder. The piston rod is bored out from the front, and is provided with a steel bush to accommodate the retarding ram. The rear end of the rod is secured to a lug on the gun by means of a steel collar and nut. The retarding ram, which is of managanese bronze, is screwed into the plug in the front end of the cylinder, and projects into the hole formed in the piston. It is provided at the end with a ball valve, which admits the liquid into the cavity of the piston during recoil, and shuts off its escape during running out. The escape is then controlled through a hole up the centre of the

ram and past a small, adjustable plug, which is accessible from the outside front end of the cylinder. The adjustment of this plug is such that the run-out of the gun is under perfect control.

The valve key is made of bronze, shaped to lie in the bottom of the cylinder. The top edge of the key, in conjunction with the piston, forms a port, through which the liquid is forced as the gun recoils. The shape of the top edge of the key is arranged so that an approximate uniform pressure is set up in the buffer during recoil.

The running-out spiral springs are placed on each side of the recoil cylinder, and are enclosed within steel cases. The springs are placed so that they can be removed or replaced without taking off the initial compression, the cap which holds them into position being fixed to the spring-case by interrupted collars. The springs are compressed to their initial load by the compressor bolt. The compressor bolt is secured to a steel crosshead, which is fixed to the lug on the breach end of the gun.



38. KRUPP AERIAL DEFENCE GUN

Sighting Gear. The sights are fitted one on each side of the mounting, and are arranged to be actuated by a separate sight-setter on the left side. A special feature of the sights are the dials with spiral grooves; these give large and clear readings for range and deflection on the circumferences. The grooves are formed in a milling machine with vertical spindle, free to revolve and with downward feed, but with a fixed vertical axis, the dial being placed horizontally on a revolving table with a cross-traverse. Thus, as the dials revolve, the cross-feed motion continually decreases, the relative distance between the centre transversely of the dial and that of the vertical milling cutter thus forming a spiral groove of equal pitch. Backlash, due to the wear of the working parts, is eliminated by the use of divided spur gear, one-half of which can be advanced to compensate the wear. A variable power, day and night sight telescope is provided on each side, and, in addition, open sights are fitted when required. An important part of the sighting arrangements on a field carriage is known as the cross levelling gear. By means of it inaccuracies in sighting due to one wheel of the carriage being higher than the other, because of rough or uneven ground, are corrected.

Ammunition. The manufacture of metallic ammunition, or cartridges, involving as it does severe punishment to the metal cases in their production, by successive pressings, drawings, and squeezings, together with a number of annealings, necessitates the use of the most ductile metal, which experience has shown to be an alloy consisting of 70 per cent. of copper and 30 per cent. of zinc. The metal, which is melted and cast into strips, is by successive rolling reduced to the required thickness, and cut into strips of a suitable width.

In the production of small cartridge-cases, the first operation consists of cutting out the blank and cupping it in a die-press. The strip of metal is automatically fed into the press by a pair of rolls, which receive an intermittent motion from a ratchet wheel and pawl. When the metal is at rest over the die, the outer or hollow punch [A in **40**] descends, cutting out the blank or disc. When this punch reaches the bottom of its stroke, the inner punch, B, then descends, pushing the disc through the die, C, and thereby forming it into a cup.

Making Cartridge Cases. To use the strip of metal in the most economical manner, and avoid any excess of scrap metal, three blanks and cups (or any greater odd number) are made at each stroke of the press, the position in plan of the punches being indicated by the dark circles in **44**, the metal being fed forward a distance slightly

39. VICKERS 4-INCH QUICK-FIRING GUN WITH FIRE CONTROL

in excess of the blank diameter after each stroke. By the three succeeding operations the cup is drawn or extended, each one reducing its diameter and the thickness of the sides or walls, and at the same time increasing the length. In the machine for this purpose the cups are fed or placed by hand into recesses in a horizontal intermittently revolving table, each in its turn coming over a die, upon which it rests. The punch, then descending therein, carries it through the die, squeezing its sides, which reduces the diameter, and at the same time extending the length. On the return stroke, the case, which at the open end expands somewhat, is stripped or pulled off the punch by the die which it previously passed through [41]. The wall of the case or shell is required to be taper, or otherwise it is necessary for the metal of the shell to be thicker at the closed end and thinner at the open end. To attain this, the drawing punches are made to taper, being smaller in diameter at the end entering the shell.

Indenting and Extending. The thickness of the metal in the end of the case has not been materially reduced, and it is now necessary (before proceeding with the drawing or extending operations) to indent the end of the case. This at the same time acts also as a preliminary heading operation, or forms the end so that an excess of metal is left therein, which will be required later. A special machine is used for this purpose. The cases are placed in an incline shoot by the attendant, and are automatically taken therefrom upon a punch or mandrel when it is coming forward, which, when at rest in the forward position, receives a blow or squeeze from a die which is held in a toggle-slide, thus forming the indent. Upon the return stroke of the punch the case extracts itself and falls into a receiving box below. The tools for indenting are shown operating in 42.

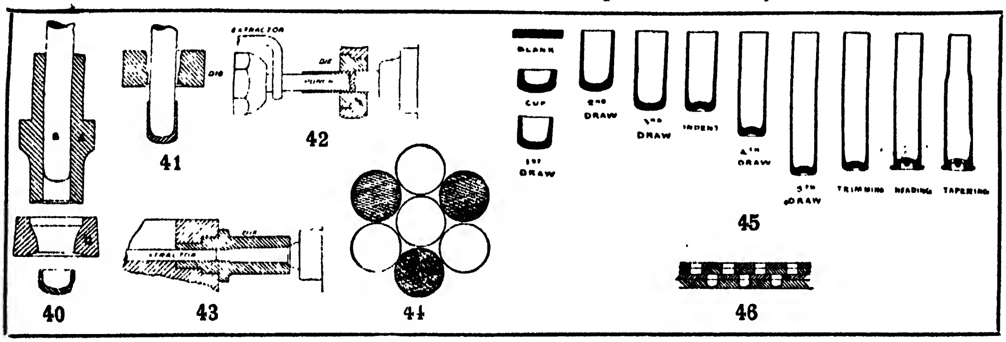
Following the indenting there are two further operations of drawing or extending to obtain a case of the required length. The open or thin end of the case or shell, through uneven annealing (which will be described later) or irregularity of the metal caused by the successive processes of drawing, becomes ragged, and always requires one or more machine trimming operations, an excess of metal being allowed in the blank for this purpose.

"Heading" and "Necking" Cartridges. The next operation consists of pressing or forming the head on the case, otherwise known as "heading." In working the heading machine the cases are fed by an attendant into a shoot, from which they are automatically taken upon a punch when making its forward stroke. As the punch, with the case upon it, comes to rest in the forward position, the toggle-jointed slide containing the die comes towards it from the opposite direction, giving it a powerful squeeze and forcing the metal to flow into the required form. Upon the return stroke of the punch, and the release of the die, the case is self-extracting, and falls into a box. The form of the end of the case before and after the "heading" operation is shown in section in 45, which also shows the various stages from the blank to the finished case. It is sometimes necessary to have a final indenting operation after the heading, so that the anvil contained in the head, and upon which the cap is struck when firing, may be properly raised, and the chamber for the reception of the cap properly formed.

Tapering, or reducing, commonly known as "necking," consists of closing in the open end of the case to a smaller diameter than the main portion of the body. In the machine for this process the cases are fed down an incline shoot in the usual manner, the one to be operated upon falling into a recess at the bottom, and being taken therefrom by a pair of fingers projecting from a rocking shaft actuated by a cam, placing it in the direct line of punch, which upon the forward stroke extracts the case from the fingers and at the same time forces the open end into a taper fixed die. A mandrel which enters the die from the opposite end following up the punch on its return stroke, positively extracting the tapered case from the die, allows it to fall into a receiver. The tools are shown in action in 43.

In some instances, where there is considerable reduction in the diameter of the open end of the case, the tapering is formed in two operations, the first taking it half-way down the die, and the second completing the work, and forming the short, sharp curve near the open end.

Piercing and Annealing Cartridges. Piercing consists of forming two small holes in the head of the case for the fire or flash from the cap. This operation is sometimes performed in a horizontal automatic drilling machine, but more frequently in a special machine. The cases are fed by hand into holes in the intermittently revolving table, and are carried under the piercing tool fixed in the top of the frame, which descends and pierces the holes. An ejector worked from the crosshead below extracts the case after piercing. Sometimes the punching is performed by two independent punches working from opposite sides of the case. The mouth or open end of the case



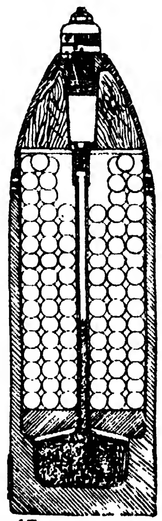
MANUFACTURE OF CARTRIDGES

40. Blanking and cupping punch and dies 41. Stripping the case 42. Indenting tools 43. Necking or tapering 44. Plan of punch and strip 45. Various stages of drawing from blank to finish 46. Fulminate plates

now requires rimering out a little, so that the bullet may readily enter. Not the least important part of the production of the cases are the numerous gauging tests which are necessary to assure accuracy.

Annealing may be defined as the release of strain in the metal which has been produced by mechanical treatment. The effect on the metal cases set up by the various drawing, heading, and tapering processes causes it to become brittle; for this reason there is a limit in the amount of work in reducing or altering the form of the area of the metal it is possible to perform at each operation. These defects of homogeneousness of structure may, however, be removed by heat treatment. The cases are heated with care, and then allowed to cool gradually. The operation of annealing may be performed either in a revolving gas-blast furnace or in larger quantities by a coal-fired turnace, the temperature of which should be between 550° and 650°.

When the cases have been annealed there is a layer of oxide on their surface, due to being heated in contact with air. This oxide is removed by dipping in acid liquids, and finally by swilling in water. The corrosion may also be due to sulphur and other foreign bodies derived from the fuel. If strong and hot aquafortis be used, the metal is liable to be dissolved and present a rough surface. For this reason a weak solution should be employed for cartridge cases.



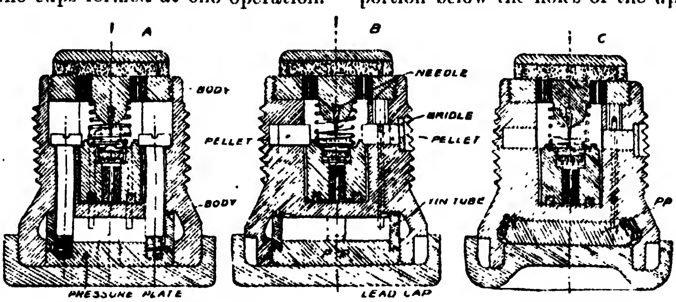
47. SHRAPNEL SHELL

Bullet-making. The next process consists of the bullet-making proper, the lead rod, which has been formed in a lead-squirting press, being automatically fed into a special machine. The rod is first sheared to the required length; it is then taken by a punch, and forced into a die which is the correct shape and form of the bullet, the finished bullet being finally extracted automatically from the die. The envelope for covering the bullet—the metal for which is an alloy of copper and nickel, better known as *cupro-nickel*—is made in a similar manner to the cartridge case; that is, the blanks are cut out and the cups formed at one operation. They then require extending, being drawn four times in succession. This leaving a rough edge at the end, a trimming process is necessary to complete the envelope. The lead cores are now placed in the envelopes and taken to the coring machine, being placed in a shoot, from which they are automatically taken between a punch and die, and the lead core being forced tightly into its envelope, the whole being self-extracting, and a completely encased bullet is delivered from the machine. In some instances two or more operations are required, the form of the conical end being thereby somewhat reduced.

As cupro-nickel tends to foul the rifle barrel very badly on firing, the modern practice, already adopted very successfully by some Powers, is to construct the envelope of nickel-plated or nickel-coated steel, or sometimes of steel by itself. The form of construction is the same as has been described, except when the bullet is made with a solid base. In this case the point is swaged over the lead core. As this leaves a hollow under the point, this bullet cannot be used for war purposes (Geneva Convention), but is a useful sporting bullet.

The cap is made of copper, and it is necessary that the metal employed be as nearly pure as possible, and perfectly soft, so that it may be formed to the necessary shape without fracture. The metal strip generally used is from ·010 to ·014 of an inch in thickness, and is cut out and formed at one operation, in a similar manner to that adopted in producing the caps for cases. In some instances the caps are trimmed or faced, this operation being performed automatically in a special cap-trimming machine. After this they are polished in a shaking or tumbling machine.

Charging Caps. They are now ready for charging, the composition employed for this purpose being fulminate of mercury, combined with other ingredients in order to ensure the ignition of the powder charge by the blow struck upon the cap. The fulminate is highly dangerous to handle, though comparatively free from danger in charging when the work is performed in a suitable machine. The caps are placed by hand into a copper plate which is provided with a number of holes of a suitable size. The plate is then put into the lower part of the charging machine, and has three brass plates above it. The plates are accurately ground together, and work with little friction. The plates are all perforated with holes corresponding in size to those in the caps [46]. The perforations in the lower plate are exactly opposite those in the caps, while those in the upper one are half-way between or over the blank portion of the lower plate. The middle plate—which is a sliding one—has its blank portion below the holes of the upper one while the latter is being charged. When the holes of the upper plate are filled with the composition, the middle plate is caused to move forward, so that its holes come under those of the upper one, taking therefrom the composition. Thus, when the holes of the lower plate communicate with those of the middle one, the caps are filled with a quantity of composition corresponding to the thickness of the centre plate.



Before firing — During flight

48. 4·72-IN. BASE PERCUSSION FUSE

It is now necessary, however, to press the fulminate of mercury composition in the charged caps. For this purpose they are taken to a pressing machine. A power-driven machine is most frequently used for this purpose, and consists of a frame having a crosshead working vertically through

the intervention of belts, gearing, and a crank shaft, and also having a table which is recessed to hold the plates containing the caps; each plate contains 1,000 caps arranged in rows of 25. The table has an automatic intermittent feed, arranged so that each row of caps is brought in its turn directly under the plungers contained in the crosshead, which then descends and presses the fulminate tightly into the cap. The row of caps, being compressed, rests upon a number of movable bases which are kept up to thei· work by counter or balance weights, so that the pressure on each cap is regulated by—and cannot exceed—that exerted by the balance weight, which can be varied to suit conditions and may be as much as 1,000 lb. on each cap.

The surfaces of the compressed fulminate—the caps still being in the receiver plate—are now covered with a small piece of tinfoil, and then varnished, the apparatus for varnishing having a plate which is covered with a solution of spirit and shellac. A number of small vertical plungers are caused by the operator to descend on the plate, each taking up a thin layer of the varnish; the plunger plate is then raised, and the varnish plate removed, the receiver containing the caps being substituted; the plungers are again brought down, and leave a thin coat of varnish on the surface of the compressed composition or fulminate. The cardboard or felt wads are made in a cutting-out press, the sheets of material being self-feeding, and the blanks are cut therefrom by a punch and die.

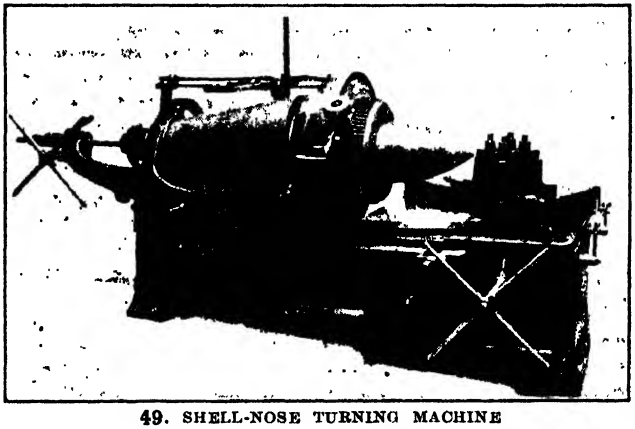
Assembling Cartridges. The various parts are now ready for assembling. The caps are embedded into their cases by a machine. These cases are placed in the long incline shoot, and the caps in the short one, a cap and case coming together at each stroke of the machine, the cap being tightly forced in. Upon the release of the pressure, they fall into the box below. In loading the case with cordite, about sixty pieces of which—somewhat resembling fine twine—are required to fill each case, the pieces are automatically cut to length, filled into the case, and pressed home. The cartridge is now ready to receive its wad and bullet, and the final operation of securing the bullet.

The complete cartridge is then cleaned and passes through the inspection stage of gauging and rectifying, and is finally weighed in an automatic machine having three receivers, one each for those of correct weight, one for lighter and one for heavier, the limit of variation being about two grains.

Shrapnel Shell. This is principally used for field and naval purposes, and one type is shown in **47**. It consists of a hollow steel case, with a solid base, filled with lead bullets. In the case of the 6-in. there are over 500 bullets. On the inside, near the base, is a shoulder for a steel diaphragm to rest upon; below this is the bursting charge, which is in communication with the fuse and head of the tube. The contact head is of brass, and contains the time fuse at its nose. This type of shell is fired out of the gun, the fuse having previously been set, and when in the air over the object—such as infantry, cavalry, or boat flotillas—the flash from the ignited fuse passes down from the fuse to the bursting charge. The bullets, etc., then fly forward with accelerated speed.

The hollow forging is bored out to the larger diameter for the bullets, and the diaphragm; and to the decreased size for the powder chamber. Then the open mouth towards the head is enlarged, and into this the finished brass head is inserted, and riveted with brass rivets. Inside the head is a wood filling plug, and at the point the time fu e is screwed in. The body is turned in the ordinary way, and the driving band compressed into the recess. The lead bullets are machine moulded, and then pressed into charcoal to fill the case.

Small Shells. Small shells—armour-piercing 6-pounder steel—are in some cases forged under the steam hammer from a round bar; in othe cases they are hollow forged and the base turned over in presses. They are then annealed and bored out. The interior inside the point is bored to a special shape, and is formed by a copying arrangement at the back of the shell. They are then rough turned on the parallel part and then the ogival, or conical head, is turned in a speci l lathe [**49**], which radiuses round the body. The shell is then reversed in the chuck and finished turned, and the groove for recess cut in to contain a driving band. There are several projections left standing up in this recess, and these are machined in the form of waves by the action of a cam acting upon the slide rest. These projections eat into the copper driving band, and the wavy contour prevents the band slipping round. The screw threads are cut into the base by a special tool.



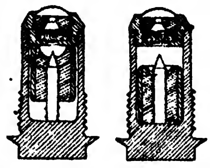
49. SHELL-NOSE TURNING MACHINE

The shells are hardened in water from the point for some distance up. The plugs are made from the bar in a hollow mandrel lathe, and are screwed tightly home into the base of the shell. The copper driving bands are compressed into the recess by a press having a relief valve, and the outsides are tapered to the front, and annular grooves are cut in them. The driving band takes the lands—or projections—and grooves of the rifling, so that the shell revolves when passing out of the gun; at the same time it obturates or makes a gas-tight joint, so that none of the powder gasses pass beyond this band. The nose is now bobbed up to the required shape by high speed emery wheels, controlled by a former saddle to give the cone shape and sharp point. They are now lacquered, inspected, and painted.

Armour-piercing Shell. This class of shell is a steel-tempered forging, with ogival-pointed head, with a small-size chamber inside for high explosive charge, and generally is fitted with a base fuse. Also many projectiles are fitted with a

soft steel cap, which protects the front and generally eases the penetration of the shell by preventing its being broken up. The operations are somewhat similar to the smaller shell.

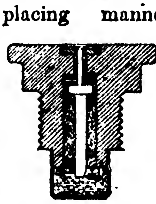
The shell is bored and counter-bored—or enlarged —inside, and the smaller diameter at the base has threads cut in it by internal milling, or by fixed cutters, to which the correct feed is given. This shell and others, after internally heating by steam, are coated with lacquer, to give a smooth internal surface to prevent premature explosions. The shell is then painted, and distinctive bands, showing the nature of the shell, are lined upon them. A semi-armour-piercing shell has thin walls, but is strong enough to withstand the shock of discharge. On striking or penetrating an object, the base percussion fuse ignites the burster and breaks the shell into fragments.



Before firing During flight

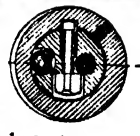
50. SMALL FUSES

Large cast steel common shell, suitable for 12-in. to 5-in. guns, are moulded with the head downwards. The mould is lined with a gannister composition, used by steelmakers to stand the high temperature. Suitable core prints are formed at each end. The hollow interior is formed by placing in a core, which is formed round a spindle. This is covered with asbestos, and over this again the "compo." To ensure sound casting, it is necessary for it to have a large superimposed head to compress the metal, and to ensure that it is fed to all parts of the shell. Moreover, the occluded gases and the poorer metal rise up into this head, which is afterwards cut off. The shells as cast are then annealed for twenty-four hours before passing on to the machine shop, where the processes that follow are somewhat similar to those for armour-piercing shell, except that they are tested by internal pressure.



51. ELECTRIC PRIMER

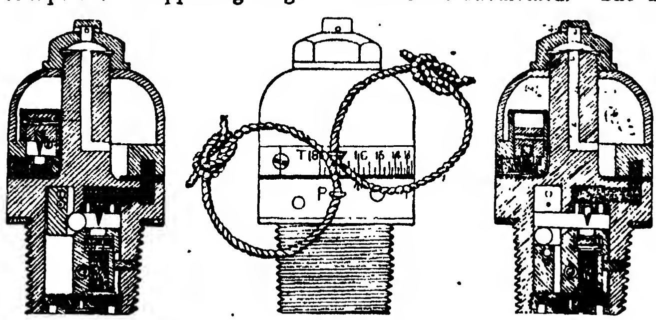
Fuses. Several types of fuses are shown in **48, 50** and **52**. The large percussion [48] consists of a stamped manganese bronze body. In firing the gun the piston pressure plate PP is blown in; this collapses the supporting ring—which is made of drawn pure tin tube—as shown in **48**. This, by pushing up the bridle, releases one of the centrifugal pellets. These pellets fly outward. The detonating pellet with its cap is then free, and lies back at the base; but on striking it moves forward, the fixed needle above piercing the cap. The flash from this ignites the powder in the pellet and that around the needle thus communicating with the burster inside the



his latter action is clearly shown during flight at C.

Small Percussion Fuses. These [50] are made of gunmetal for the small sizes, and steel for the larger. They contain the detonating composition in a recess in front. Below this is the lead guard pellet, supported by the roughened steel or brass needle that is embedded in it. On the shock of discharge the inertia of the lead guard causes it to set back, arming the needle—that is, causing its point to protrude. During flight the guard, with its projecting needle, lies backwards against the base of the fuse; but on impact it moves freely forward, the needle piercing the detonator and igniting the bursting charge in the shell. The smaller type of fuses are manufactured from rods in turret lathes with hollow mandrels and rod feed. In some later types of machines no less than four rods are manipulated at one time. It is impossible to describe the numerous types of fuses, such as delay action, also electric primers—for one type of which see **51**—within the scope of this article. But the combined time and percussion fuse will be described briefly.

Combined Time and Percussion Fuse. This fuse [52] is used principally with shrapnel shell. The composition must burn in a regular manner, and is set to act by time at very short intervals. The principal parts of the time arrangements consist of the body, composition ring, and dome. In addition to this there is a percussion arrangement at its lower portion, to enable the shell to burst on impact in case of failure of the time fuse. This fuse is screwed on the exterior to fit into the shell, and bored out to take the percussion arrangement. The body extends upwards through the dome. The composition lies in the central belt of the body with a ring above it also containing the lighting composition and the hammer, with a steel needle suspended by a copper wire above the composition. There is a hole bored through the ring near the start of the composition channel to allow the gas to escape. The outside of the ring is divided into eighteen half-seconds time of burning. These are further subdivided. The dome fits over the composition ring, and is held in place by the nut screwed on to the stem on top of the body. The action of this time part is such that, when the fuse is set, the shock of discharge causes the hammer to shear the wire, and fire the detonator and composition ring, which burns round the distance required, firing the charge in the horizontal channel, and the bursting charge in the lower chamber of the shell by passing down the primer tube, and thus explodes the shell. The percussion part is shown "before firing" and "during flight," to illustrate its action.



Before firing During flight

52. COMBINED TIME AND PERCUSSION FUSE

Either portion of this fuse can be used as desired, for time or percussion. The body is made out of bronze bar in a hollow mandrel lathe.

JOHN W. WAINWRIGHT

The Working Principles of the Various Machines. · Care of Machine. The Standard Keyboard. Touch. Fingering.

THE TYPEWRITER AND ITS PARTS

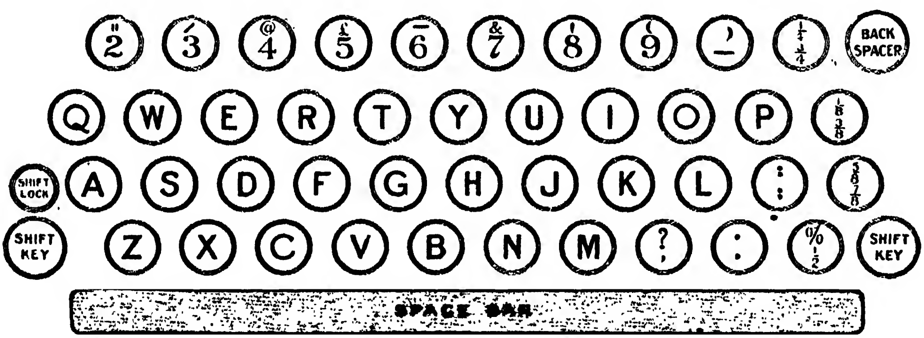
In this course it is intended to deal with the business of typewriting in such a way that the student may be enabled to apply the general principles set out to any particular machine he wishes to use.

There is great similarity in the construction of typewriters, and a general knowledge of the fundamental principles of one machine will, to a large extent, apply to all makes.

The Mechanism. In the first place it is necessary to understand something of the process which goes on from the time the key is depressed to the actual impression as we see it on the paper. There is nothing very complicated in a typewriter, but sometimes the simplest misplacement of a part will make good work a sheer impossibility; and as it is not always convenient to wait for help, a little trouble in the beginning is its own reward.

From each key a lever projects horizontally to the rear. From the middle of this rises a connecting rod, at the end of which is a type bar, corresponding with the letter on the key. This key-lever is pivoted, so that when the key is depressed, the type bar approaches the printing point, and the type at its end strikes the ribbon, leaving an impression on the paper. Obviously another movement is now necessary to prevent the next letter striking the paper in the same place. This is effected automatically in this way. Under all the key-levers is a horizontal bar, extending from side to side in the machine, so that when a key is depressed, the bar also is depressed. The latter pulls down its connecting rods, and they in turn rock an escapement, the most important feature of which is the *dogs*, one of which is loose, and the other rigid. These dogs, when they rock, allow the carriage to move the width of one letter, so that at each step the type prints at a different point. The force necessary to pull the carriage along is supplied by a mainspring, which is automatically wound up every time the carriage is pulled to the right. The movement, step by step from right to left, is governed by the action of the dogs as already described.

The art of typewriting is so apparently easy that pupils are apt to underestimate the difficulties which await them; and this is the cause of much of the unsatisfactory workmanship of which business men so frequently complain. Too little time is given to study, and the result is work which can give satisfaction neither to the typist nor to the person for whom it is done. There can be little pleasure for the operator who has to turn out a considerable amount of work a day if that work, through incompetency, is irksome. Whatever difficulties have to be overcome are very materially minimised if the typist is master of the machine; and the effect of a batch of beautiful, regular manuscript is ample reward for a hard day's work, whatever it may have cost in labour.



THE "STANDARD" KEYBOARD

Choice of a Machine. It is difficult, and perhaps unnecessary, to offer advice on the selection of a machine. There are four or five machines on the market which are pretty certain to turn out good work. But the matter of price, which is a consideration with most people, is a difficulty which has still to be overcome. For the man who can produce a reliable machine at half the cost of those at present available there is a fortune which has been waiting for years. A typewriter, even the cheapest, is not an inexpensive luxury. The cost of any of the leading makes runs to about twenty-one guineas, although, for certain purposes, some of the cheaper ones offer all the facilities needed.

As far as the make is concerned, the choice turns practically on three points—*viz.*, type, double or single keyboard, and price. The type is distinctly a matter of taste. Some people prefer a small, neat type; others find

merits in a larger one. So that the only serious point to be considered is whether a double keyboard is preferable to a single one. On this point experts disagree, but, as most of the newer patterns have the single keyboard, there is apparently a growing preference for this class of machine.

Sometimes a machine may require to be carried from one place to another, when consideration must be paid to its weight. But for ordinary commercial purposes the choice is mainly one of taste. Any of the leading makes—Remingtons, Smith-Premiers, Yosts, Barlocks, Olivers, and others—will give good results, provided, of course, that the machine is handled by a skilful operator.

Care of the Machine. The importance of keeping the machine absolutely free from dust cannot be too highly insisted upon. No machinery is impervious to the effect of dirt, and if a typewriter is to give good value for the money expended upon it, great attention must be given to this point.

In the first place, it should be thoroughly dusted each day, and the "way" rods rubbed over with a greasy rag. The use of too much oil is as bad as, if not worse than, too little, and this should not be forgotten in oiling all parts of the machine. The "dogs" should be lubricated, say, once a week, and the "type bar bearings," etc., very occasionally. For this, a small oil-can which the makers supply should be used; and any superfluous oil remaining on the parts should be wiped off. When dirty, the type itself should be brushed, and, as often as necessary, the dirt which will accumulate in the centre of the letters should be *pricked* out with a brush.

The Keyboard. When the student has made himself as familiar with the mechanism of his machine as possible, he should turn his attention to a study of the keyboard. He will notice that the alphabet is not arranged consecutively from A to Z, but in a way which allows certain convenient combinations of letters to come together. The standard keyboard is the result of the arrangement finally adopted by experts as the best possible for facility and speed, allowing, at the same time, alternate manipulation of the hands.

The arrangement also prevents, as far as this can be done, the possibility of the type bars clashing one against the other when working at a high speed—say, of 70 or 80 words a minute.

Single and Double Keyboard. In machines which have a double keyboard, the working is easily understood, but to a beginner the "shift" key of a single keyboard may at first present some difficulty.

In a Remington, for example, there is only one shift key, which is duplicated for either hand. The keys, as they stand, represent the small letters. Each type letter has two characters; by pressing down the shift key with one finger the carriage is moved forward, allowing the capital letters—or figures, as the case may be—to come into gear, and print through the ribbon on to the paper.

In other makes the keyboard has two shift keys, in which case one is confined to capital letters and the other to figures and punctuation marks.

In spite of the fact that the standard keyboard appears on nearly every machine on the market, for special commercial or foreign work special keys can be substituted for others which may be useless to the operator. Accents for foreign words, for example, can always be added to a machine at very little additional expense.

Ribbons. Ribbons can be purchased from the makers who supply the machine. They cost 3s. each, but a reduction is offered if half a dozen are purchased at a time. To the uninitiated this may sound somewhat alarming; but, as a matter of fact, a ribbon lasts a considerable time; it moves with the carriage as each key is depressed, so that the wear caused by the continuous striking is evenly distributed along its whole length. In some of the newer machines this movement extends from top to bottom of the ribbon in addition, so that every part does full service.

The ribbon is held by means of a "spool" on either side of the instrument, and the ends are caught by little metal clips. These are very simple in construction, and quite easily adjusted when the ribbon requires to be replaced by a new one.

All makers supply copying and non-copying ribbons. It is also possible with some makes to use two-colour ribbons, which sometimes help to improve the appearance of special work.

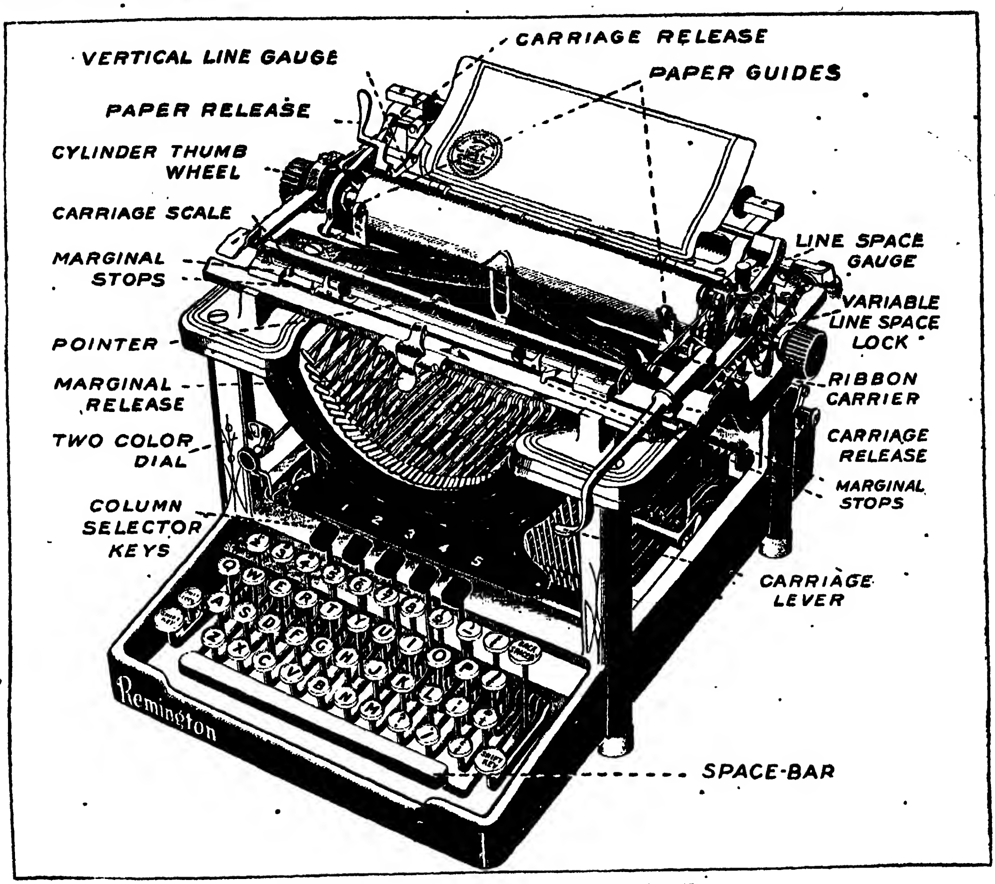
Feeding. In feeding the machine—that is, fixing the paper in position—it should be noticed that, in order to get it the right way up, the paper should be held behind the roller upside down, with the heading towards the machine, and then inserted in position between the "paper-shelf" and the roller.

If the paper in use happens to be a plain sheet, it will not, of course, matter which end is fed into the machine, except that the student should always remember to use the *right* side of the paper. The wrong side of a sheet is rougher and generally less shiny than the other, so that it can be readily distinguished. A sure way, when possible, of finding the right side of a sheet is to notice the water mark, and to write on that side on which the wording reads correctly.

The Bell. Every machine has a bell, which rings automatically, and acts as a warning to the operator that he has nearly reached the end of the line. In this way he is enabled to judge the best way of splitting up certain words which may have to be divided.

There is no such convenient device for telling the operator when he has reached the bottom of a sheet; but experience will soon teach him, by the hollow sound which he will quickly learn to recognise, that the line he is writing is the last one which the paper can take.

Touch. We have now reached one of the most important considerations in our study. To ensure perfect work it is not sufficient merely to depress the keys. In the first place the operator must realise the importance of touch—



THE IMPORTANT PARTS OF A TYPEWRITER

that is, he must remember that nothing is so essential in typewriting as the cultivation of a firm, even touch. The hands should be held as close to the keyboard as possible, and the key struck sharply and then instantly withdrawn. This is not quite so simple as it sounds, when it is remembered that the depressions must be very evenly timed, as the student will acknowledge when he begins to acquire speed.

Accuracy and touch must *never* be sacrificed to speed; when the student realises this truth he will have mastered the first essential of good work. Punctuation keys should be struck much more lightly than others, so as to avoid the marks which one sometimes sees on the back of imperfect copy.

Fingering. The question of fingering is one which has caused no small amount of controversy among experts. How many fingers shall be used? And how shall the keyboard be portioned out to each?

The thumbs are, of course, reserved for the "space bar," right or left hand being used as is most convenient.

It would not be wise to lay down a hard and fast rule for fingering, especially as we are not dealing with any machine in particular. The point to be remembered is that one should endeavour to use as many fingers as possible, in order to cover the keyboard in the shortest possible amount of time. The first, second, and third fingers should certainly be used, though it is quite true that high speed is attained by operators who advocate the use of two fingers only. If, after a reasonable amount of practice, the student finds any difficulty in using the third finger, he should certainly abandon the idea, and employ only the first and second.

The first fingers, being naturally the strongest, should monopolise the greatest proportion of the keys in the centre of the keyboard, the remainder being split up for the other fingers. If the student *at the beginning* marks out for himself such a plan of fingering, and keeps rigidly to it until it is familiar to him, he will find that each finger unconsciously confines itself to its own particular letters, and he will be laying the truest foundation for the acquisition of speed.

There are not many operators who are able to use four fingers, but it is a consideration from the point of view of speed if this can be done. In the case of single keyboards the little finger is used for depressing the shift keys.

MARGARET LILLIE

Simple Equations. Definitions. Simultaneous Simple Equations of the First Degree containing Two and Three Unknown Quantities.

ALGEBRAIC EQUATIONS

SIMPLE EQUATIONS

43. An *equation* states that two algebraical expressions are equal. The two expressions are called *sides* of the equation.

If, however, the two expressions are equal for *all values* of the letters involved, the equation is generally called an *identity*. The name *equation* is applied to the cases in which the expressions are only equal for some particular values of the letters involved.

For example,

$$(x + a)(x + b) = x^2 + (a + b)x + ab$$

is an identity, since these two expressions are always equal whatever the values of x, a, and b may be.

$$3x + 7 = 2x + 9$$

is an equation, since the two expressions $3x + 7$ and $2x + 9$ are only equal in the particular case where $x = 2$.

44. In the latter example, x is called the *unknown quantity*. The process of finding the value, or values, of the unknown quantity for which the equation is true is called *solving* the equation. These values are called the *roots* of the equation, and are said to *satisfy* the equation.

It is usual to express unknown quantities, whose values have to be found, by letters from the *end* of the alphabet, x, y, z. Quantities whose values are supposed to be known are represented by letters from the *beginning* of the alphabet, a, b, c.

45. If equations contain only the *first* power of the unknown quantities they are called *simple* equations, or equations *of the first degree*.

We shall first consider equations which contain only one unknown quantity.

Suppose we have to solve the equation

$$4x - 3 = 2x + 7. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Since these two expressions, $4x - 3$ and $2x + 7$, are equal, the results obtained by subtracting $2x$ from each of them will be equal.

Therefore

$$4x - 3 - 2x = 2x + 7 - 2x;$$

or,

$$4x - 3 - 2x = 7.$$

Again, if we now add 3 to each side of the equation, the two sides will still be equal.

Hence,

$$4x - 3 - 2x + 3 = 7 + 3;$$

or,

$$4x - 2x = 7 + 3. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Compare the result (2) with the original equation (1). Each contains the same terms, but in (2) the terms which contain x are on one side of the equation, and the numerical terms are on the other. Also, we see that the term $2x$ in (1) is on the right, and is $+$, while in (2) it is on the left and is $-$. Similarly, -3 on the left of (1) becomes $+3$ on the right of (2). That is, *we may move a term from one side of an equation to the other, provided we change its sign.* A term which is moved from one side to the other is said to be *transposed*.

If we now collect the terms on each side of (2) we get

$$2x = 10;$$

and it is clear that if we divide equal quantities by the same quantity, the quotients will be equal. Hence, we now divide both sides of the equation by 2, and obtain the result $x = 5$.

46. The essential part of the process, then, is to put all terms which contain the unknown quantity on to one side of the equation, and all other terms on to the other side, remembering that when we transpose a term we must change its sign. We then collect the terms on each side of the equation, and, finally, divide both sides by the coefficient of the unknown quantity.

Very often, however, the equation requires some simplification before we are able to transpose the terms, as will be seen from the following examples:

Example 1. Solve $4(x - 3) - x = 2(x - 1)$.

Here we must first remove the brackets. Thus,

$$4x - 12 - x = 2x - 2.$$

Transposing,

$$4x - x - 2x = -2 + 12.$$

Collecting terms,

$$x = \underline{10} \; \textit{Ans.}$$

The student can always *verify* his results—*i.e.*, test whether the value found does satisfy the equation—by substituting the value in both sides of the equation.

Thus, in Example 1, if we put $x = 10$ in the left side of the equation, we obtain

$$4(10 - 3) - 10, \text{ which equals } 18.$$

Again, putting $x = 10$ in the right side of the equation we get $20 - 2$, or 18. Since the two results agree, we know that the solution is correct.

Example 2. Solve

$$\frac{x+1}{2} + \frac{2x-3}{3} = 5 - \frac{3x-1}{4}.$$

It is evident that if the sides of the equation are equal, the products obtained by multiplying both sides by the same quantity will be equal. We multiply all through by 12, the L.C.M. of the denominators 2, 3, 4, and thus get rid of the fractions.

For $\frac{12(x+1)}{2}$ equals $6(x+1)$,

$\frac{12(2x-3)}{3}$ equals $4(2x-3)$,

and so on.

Hence, the working of our equation is written out as follows,

Clearing fractions,

$$6(x+1)+4(2x-3)=60-3(3x-1),$$

or,

$$6x+6+8x-12=60-9x+3.$$

Transposing,

$$6x+8x+9x=60+3+12-6.$$

Collecting terms,

$$23x=69.$$

Dividing by 23,

$$x=\underline{3\ Ans.}$$

With a little practice, the fractions are cleared and the brackets removed in the same process. The chief point to remember is that if a fraction has the sign $-$ before it, the signs of the numerator must be changed when we clear the fractions. For instance, in the above $5-\frac{3x-1}{4}$ became $60-9x+3$, *not* $60-9x-3$.

Example 3. Solve

$$a(x+b)+b(x-a)=a^2-b^2.$$

Removing brackets,

$$ax+ab+bx-ab=a^2-b^2.$$

Collecting terms,

$$(a+b)x=a^2-b^2.$$

Divide by $(a+b)$, the coefficient of x; then

$$x=a-b\ \underline{Ans.}$$

Example 4. Solve

$$(x+1)(x+3)+(x+2)(x+4)=2(x+3)^2.$$

Removing brackets, Art. 31,

$$x^2+4x+3+x^2+6x+8=2x^2+12x+18.$$

Transposing,

$$x^2+4x+x^2+6x-2x^2-12x=18-3-8.$$

Collecting terms,

$$-2x=7.$$

Dividing by -2,

$$x=-\underline{3\tfrac{1}{2}\ Ans.}$$

EXAMPLES 7

Solve the following equations:

1. $5(2x-1)-3(x+4)=3(x-3)$.
2. $3(1-x)-2(3+5x)+x=0$.
3. $\frac{x}{2}-\frac{x}{3}=2$.
4. $\frac{1}{2}(x-2)-\frac{1}{3}(x+4)=\frac{1}{6}(5x-2)$.
5. $3(x+1)^2+4(x-3)^2=7(x-1)^2$.
6. $\frac{x+\frac{1}{4}}{2}-\frac{3x-\frac{1}{4}}{4}=\frac{x-\frac{3}{4}}{3}$.
7. $5x-\{6-2(2x-3)-x\}=2(1-2x)$.
8. $(x+a)^2-(x+b)^2=(a-b)^2$.
9. $\frac{a}{x}+\frac{b}{x}=c(a+b)$.
10. $(x+a)^3+(x+b)^3+(x+c)^3=3(x+a)(x+b)(x+c)$.

SIMULTANEOUS SIMPLE EQUATIONS

47. So far, our equations have only contained *one* unknown quantity. If an equation contains *two* unknown quantities, we can find as many pairs of values of the unknown quantities as we please which will satisfy the equation.

For, consider the equation

$$2x-3y=2.$$

From this we see that $2x=3y+2$, and therefore $x=\frac{1}{2}(3y+2)$. Hence, if we give y any value we please, we obtain a corresponding value for x.

Similarly, if we have a second equation, containing the same unknown quantities x and y, such as

$$x+3y=10,$$

we know that $x=10-3y$, and we are again able to find as many pairs of values of x and y as we please which will satisfy the equation.

But, if both equations are to be satisfied by the *same values of x and y*, then the two expressions $\frac{1}{2}(3y+2)$ and $10-3y$ must evidently be equal.

Thus

$$\tfrac{1}{2}(3y+2)=10-3y,$$

and, if we solve this equation by the methods of Art. **46**, we find that $y=2$. Therefore, since we know that $x=10-3y$, we have $x=10-6=4$.

Hence we see that if the equations

$$2x-3y=2$$
$$x+3y=10$$

are to be satisfied by the *same* values of x and y, the only solution possible is $x=4$, $y=2$.

48. Two or more equations which are to be satisfied by the same values of the unknown quantities are called *simultaneous equations.*

The *degree of an equation* containing two unknowns, x and y, is the degree of that term which is of the highest dimensions in x and y. [Art. **29.**]

Thus,

$2x-3y=2$, is of the *first* degree.

$3xy+4=10x$, is of the *second* degree.

Similarly, if there are three unknowns, x, y, and z, the term of highest dimensions in x, y, and z determines the degree of the equation; so that $x+2y+3z=0$ is of the first degree, and $ax^2+byz=cx$ is of the second degree.

49. For the present we shall only consider equations which are of the first degree. We shall see that to find the values of *two* unknowns we require *two* equations, to find *three* unknowns we require *three* equations, and so on.

Example 1. Solve the equations,

$$4x-3y=18. \quad . \quad . \quad . \quad . \quad (1)$$
$$3x+2y=5. \quad . \quad . \quad . \quad . \quad (2)$$

For the sake of reference it is convenient to number our equations.

Our object must be to form an equation, by the aid of (1) and (2), in which either the x or the y is wanting. The process by which we do this is called *elimination*, and the unknown quantity thus got rid of is said to be *eliminated.*

Suppose we eliminate y. In (1) the coefficient of y is 3, in (2) it is 2. The L.C.M. of these coefficients is 6. We can, therefore, by multiplication, make 6 the coefficient of y in each equation. Hence, multiply (1) by 2, and (2) by 3, and we get

$$8x - 6y = 36. \quad . \quad . \quad . \quad . \quad (3)$$
$$9x + 6y = 15. \quad . \quad . \quad . \quad . \quad (4)$$

It is clear that if we now *add* the corresponding sides of the equations (3) and (4) we shall eliminate y.

Thus,

$$17x = 51.$$

Therefore, dividing by 17, we have

$$x = 3.$$

We can eliminate x in a similar way from the equations (1) and (2) and so obtain the value of y. Or, knowing the value of x, we can substitute this value for x in either (1) or (2), which is often a simpler elimination than the other.

Substituting the value of x in (1), we have

$$12 - 3y = 18.$$

Therefore,

$$3y = 12 - 18$$
$$= -6$$

so that,

$$y = -2.$$

Thus, the required solution is $x = 3$, $y = -2$.

Example 2. Solve the equations

$$\tfrac{1}{3}(x-1) = \tfrac{1}{4}(y+1). \quad . \quad . \quad . \quad (1)$$
$$\frac{2x-3}{5} + \frac{2y-13}{7} = 0. \quad . \quad . \quad . \quad (2)$$

We must first clear the fractions, as in Ex. **2**, Art. **46**, and transpose the terms. Thus,

Multiply (1) by 12,

$$4x - 4 = 3y + 3.$$

Therefore,

$$4x - 3y = 7. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Multiply (2) by 35,

$$14x - 21 + 10y - 65 = 0.$$

Therefore,

$$14x + 10y = 86. \quad . \quad . \quad . \quad . \quad (4)$$

We now solve the equations (3) and (4) just as we did Ex. **1** above. Multiply (3) by 10 and (4) by 3, and add.

Then,

$$40x + 42x = 70 + 258\,;$$

or,

$$82x = 328.$$

Therefore,

$$x = 4.$$

Substitute this value in (3).

Then,

$$16 - 3y = 7,$$
$$-3y = -9.$$

Therefore,

$$y = 3.$$

We thus have

$$\left.\begin{array}{l} x = 4 \\ y = 3 \end{array}\right\} \underline{Ans.}$$

Example 3. Solve

$$(b+c)x + (b-c)y = 2ab. \quad . \quad . \quad . \quad (1)$$
$$(c+a)x + (c-a)y = 2ac. \quad . \quad . \quad . \quad (2)$$

We eliminate y in exactly the same manner as before.

If we multiply (1) by $(c-a)$ and (2) by $(b-c)$ the coefficient of y will become $(b-c)(c-a)$ in each case.

Hence, multiply (1) by $(c-a)$ and (2) by $(b-c)$ and subtract.

Then,

$$\{(b+c)(c-a) - (c+a)(b-c)\}\,x = 2ab\,(c-a) - 2ac\,(b-c).$$

Therefore,

$$\{bc - ab + c^2 - ac - bc - ab + c^2 + ac\}\,x = 2abc - 2a^2b - 2abc + 2ac^2.$$

Collecting terms,

$$2\,(c^2 - ab)\,x = 2a\,(c^2 - ab).$$

Dividing by $2\,(c^2 - ab)$,

$$x = a.$$

Substitute the value of x in (1).

Then,

$$(b+c)\,a + (b-c)\,y = 2ab.$$

Therefore,

$$(b-c)\,y = 2ab - ab - ac,$$
$$= a\,(b-c)$$

Dividing by $b-c$,

$$y = a.$$

Therefore,

$$x = y = a \quad \underline{Ans.}$$

Sometimes it is more convenient to solve for $\frac{1}{x}$ and $\frac{1}{y}$, as in the following example :

Example **4**.

$$\frac{4}{x} - \frac{3}{y} = -3. \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{2}{x} + \frac{6}{y} = 1. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Multiply (1) by 2, and add (2), then

$$\frac{8}{x} + \frac{2}{x} = -6 + 1,$$

$$\frac{10}{x} = -5.$$

Divide by 5,

$$\frac{2}{x} = -1.$$

Therefore,

$$x = -2.$$

Again, multiply (2) by 2, and subtract (1), then

$$\frac{12}{y} + \frac{3}{y} = 2 + 3,$$

$$\frac{15}{y} = 5.$$

Divide by 5,

$$\frac{3}{y} = 1.$$

Therefore,

$$y = 3.$$

Solution is

$$\left.\begin{array}{l} x = -2 \\ y = 3 \end{array}\right\} \underline{Ans.}$$

Beginners are often confused by the equations being given in the following form.

Example 5. Solve $3x + 4y - 6 = x - 2y - 8 = 5y - x + 16$.

Since
$$3x + 4y - 6 = x - 2y - 8,$$
we have
$$2x + 6y = -2. \quad . \quad . \quad . \quad . \quad (1)$$
and since
$$x - 2y - 8 = 5y - x + 16,$$
$$2x - 7y = 24. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

By solving (1) and (2) we obtain $x = 5$, $y = -2$.

50. Let us now consider three simultaneous equations of the first degree containing three unknown quantities, x, y, and z. In the same way as already explained, we can eliminate one of the unknowns, say z, from two of the equations. Then, from one of these equations and the third equation, we can also eliminate z. We thus obtain two equations containing only two unknowns, x and y, and these can be solved as in the last Article.

Example 1. Solve the equations,
$$2x + 3y + z = 7. \quad . \quad . \quad . \quad . \quad (1)$$
$$3x - y - 2z = 3. \quad . \quad . \quad . \quad . \quad (2)$$
$$x + y - 3z = 6. \quad . \quad . \quad . \quad . \quad (3)$$
Multiply (1) by 2, and add (2), then
$$7x + 5y = 17. \quad . \quad . \quad . \quad . \quad (4)$$
Multiply (1) by 3, and add (3), then
$$7x + 10y = 27. \quad . \quad . \quad . \quad . \quad (5)$$
By solving (4) and (5) we obtain
$$x = 1,\ y = 2.$$
Substitute these values in (1), then
$$2 + 6 + z = 7.$$
Therefore,
$$z = 7 - 6 - 2 = -1.$$
Thus, the solution is
$$x = 1,\ y = 2,\ z = -1 \text{ Ans.}$$

Example 2. Solve the equations
$$\frac{1}{y} + \frac{1}{z} = 7. \quad . \quad . \quad . \quad . \quad (1)$$
$$\frac{1}{z} + \frac{1}{x} = 6. \quad . \quad . \quad . \quad . \quad (2)$$
$$\frac{1}{x} + \frac{1}{y} = 5. \quad . \quad . \quad . \quad . \quad (3)$$
Here, it is shorter to work as follows: Add the three equations, then
$$2\left(\frac{1}{x} + \frac{1}{y} + \frac{1}{z}\right) = 18;$$
or,
$$\frac{1}{x} + \frac{1}{y} + \frac{1}{z} = 9. \quad . \quad . \quad . \quad . \quad (4)$$
Subtract (1) from (4), and we get
$$\frac{1}{x} = 2.$$
Therefore,
$$x = \tfrac{1}{2}.$$
Similarly, subtracting (2) and (3) in turn from (4), we get $\frac{1}{y} = 3$, and $\frac{1}{z} = 4$, so that $y = \frac{1}{3}$, $z = \frac{1}{4}$.

EXAMPLES 8

Solve the following equations.

1. $x + y = 8$
   $x - y = 2.$
2. $2x + y = 2$
   $x - 2y = 11.$
3. $3x - 4y = 1$
   $5x + 3y = 21$
4. $2x = 9 - 3y$
   $5y = 24 - 6x.$
5. $2x + 3y = 3x + 2y = 25.$
6. $\dfrac{5 + x}{3} = \dfrac{7 + y}{5} = \dfrac{9 + x + y}{7}.$
7. $\dfrac{x}{15} + \dfrac{y}{12} = \dfrac{x}{3} - \dfrac{y}{4} = 1.$
8. $\dfrac{x - y}{2} - \dfrac{3x - \frac{1}{2}y}{5} = \frac{1}{2}$ $\quad \dfrac{x}{3} - \dfrac{y}{2} = 2.$
9. $\dfrac{6}{x} - \dfrac{5}{y} = 8$
   $\dfrac{4}{x} + \dfrac{3}{y} = -1.$
10. $2x - \dfrac{5}{y} = 3$
    $x - \dfrac{6}{y} + 2 = 0.$
11. $ax + by = bx + ay = a^2 - b^2.$
12. $bx = ay$
    $ax + by = a^2 + b^2.$
13. $y + z = 7$
    $z + x = 5$
    $x + y = 8.$
14. $2x - y + z = -4$
    $3x + y + 2z = -2$
    $x + y + z = 1.$
15. $\dfrac{1}{x} + \dfrac{1}{y} - \dfrac{1}{z} = 0$ $\quad \dfrac{1}{x} - \dfrac{1}{y} + \dfrac{1}{z} = 4$
    $\dfrac{5}{x} + \dfrac{1}{y} + \dfrac{1}{z} = 20.$

Answers to Algebra

EXAMPLES 7

1. $x = 2$. 2. $x = -\frac{1}{4}$ 3. $x = 12$.

4. Multiply both sides by 6, obtaining $3x - 6 - 2x - 8 = 5x - 2$, whence $x = -3$.

5. $3(x^2 + 2x + 1) + 4(x^2 - 6x + 9) = 7(x^2 - 2x \times 1)$. Therefore $6x - 24x + 14x = -3 - 36 + 7$, giving $x = 8$.

6. Multiply by 12. Then $6(x + \frac{1}{4}) - 3(3x - \frac{1}{4}) = 4(x - \frac{3}{4})$, so that $6x - 9x - 4x = -3 - \frac{3}{4} - \frac{6}{4}$. Therefore $-7x = -\frac{21}{4}$ and $x = \frac{3}{4}$.

7. $x = 1$.

8. $(x + a + x + b)(x + a - x - b) = (a - b)^2$ [Art. 34], or $(2x + a + b)(a - b) = (a - b)^2$, Divide both sides by $(a - b)$. Then $2x + a + b = a - b$. Whence $x = -b$.

9. Multiply both sides by x. Then $a + b = cx(a + b)$. Divide both sides by $(a + b)$, and we get $1 = cx$, or $x = \dfrac{1}{c}$.

10. Removing brackets, we have
$$x^3 + 3ax^2 + 3a^2x + a^3$$
$$+ x^3 + 3bx^2 + 3b^2x + b^3$$
$$+ x^3 + 3cx^2 + 3c^2x + c^3 = 3x^3 + 3x^2(a + b + c)$$
$$+ 3x(bc + ca + ab) + 3abc.$$
Collecting terms, $3x(a^2 + b^2 + c^2 - bc - ca - ab) = -(a^3 + b^3 + c^3 - 3abc)$.

Divide both sides by $3(a^2 + b^2 + c^2 - bc - ca - ab)$ and $x = -\frac{1}{3}(a + b + c)$. H. J. ALLPORT

THE MOST POWERFUL FORCES IN THE WORLD—FIRING THE GUNS OF A DREADNOUGHT

WHEN THE WHOLE TEN GUNS ARE FIRED ON SUCH A SHIP AS THIS THE EXPLOSION IS SO TERRIFIC THAT THE HEARING OF THE MEN IS IMPERILLED, AND MUST BE PROTECTED BY PACKING THE EARS WITH COTTON-WOOL. We are enabled to publish this fine photograph by courtesy of Messrs. Armstrong, Whitworth & Co.

FACING PAGE 2777

Ideas Waiting for the Inventors of the Future in the Development of Engines and Machinery

THE FIELD OF INVENTION

SOME of the surest paths to personal success, for men of ingenious mind, cross the broad fields of modern invention. In the next hundred years a good many sources of power may be put to better use; new sources may to some extent become available, and streams of energy now running to waste be harnessed in the service of man. Already some important attempts have been made to utilise the direct heat of the sun in tropical countries with cloudless skies by means of a sun-plant, one of which is now working in Egypt. And the force of gravity, derived from the moon and applied to the sea against the force of earth gravity, is being used in a large way in a great tidal plant off the coast of Northern Germany. But the development of these sources of waste power in tropical sunlight, sea tides, and tidal rivers scarcely comes within the field of invention at the present day. Not until our present supplies of fuel are seriously exhausted, and our mechanism for the transmission of power is greatly improved, will the exploitation of the direct heat of the sun and the daily surge of the tide become a necessity.

Still more remote is the prospect of tapping the central, infinite store of energy in the universe—the electrical forces locked up in every atom of matter. Any stone by the wayside, it has been said, contains sufficient electrical energy to light a town and drive its vehicles for a whole day and night, but it is possible that man may never find a means of cheaply liberating and fully controlling the electric forces of the atom.

Meanwhile, the inventor has a large field for the exercise of his genius in the problem of finding a good, cheap, and abundant substitute for petrol. Last year, in the United Kingdom alone, motor-cars used about a hundred million gallons of petrol, and it is reckoned that our road transport will soon consume annually 250 million gallons at least. What the demand will be in fifty years' time is incalculable. It is generally admitted that alcohol is the best substitute, and the first thing needed in connection with it is a method of rendering the spirit unfit for drinking without diminishing its explosive power or adding appreciably to its cost.

A constantly good potato-crop for the production of alcohol on a large scale may soon become a commercial necessity in temperate climates, and it is quite probable that agricultural villages will be able to develop their industries by means of alcohol obtained from their own fields.

Then in regard to oil-engines, there is a new source of power in various kinds of vegetable oil. When Dr. Diesel exhibited one of the first of his engines in Paris, some years ago, he ran it on a vegetable oil extracted from the arachis nut, which grows in the French territories in Northern Africa. It is quite likely that the use of vegetable oils of this sort will increase, more especially for engines of the heavier and stationary type.

There is a valuable source of fuel-oil, too, in the many deposits of cannel coal and shale, and a promising beginning has recently been made with a new process by which motor spirit can be produced from cannel coal at a cost of less than 1½d. a gallon. It is reckoned that our country contains, in cannel coal and shale, more than 3600 million gallons of petrol; and if this can be distilled by a fairly inexpensive process it will render us independent of foreign supplies, and free our motor traffic from the grip of the oil combines. Such methods of distillation, however, will only provide our motor transport with fuel for a quarter of a century, or less; and for a continuous supply of spirit at a reasonable price we must look to advanced methods of manufacturing alcohol from cheap and abundant vegetables.

Oil and spirit fuel, however, are only useful in a small way. They are important in the lighter forms of transport and in the driving of small pieces of machinery, by reason of their portable and handy

character. But for some hundreds of years the main work of the world will be done on coal, and what is most urgently needed at present is a more effectual method of utilising our largest so rce of power. The actual amount of useful work obtained from coal by the latest and best plant is only about 20 per cent. of its total latent energy. The other 80 per cent. is dissipated and wasted in places where it is not wanted. New kinds of engines are required in which coal or coal gas can be made to produce more work.

There appear to be two directions in which the waste of energy can partly be prevented—the principle of the engine can be changed, or its manner of working be altered. The heat of the coal or of its gas can be applied in a more direct manner to the work of converting water into steam. This has the advantage of providing man with a very convenient stream of power which can be controlled much better than the explosive force of gas. The gas-engine, on the other hand, is more powerful than the steam-engine in the sense that it will get more work out of the heat energy contained in a given amount of coal.

But leaving for the moment the problem of the production of power from coal, there is an important preliminary question of the economical transmission of power. Usually, the steam of a steam-engine, or the exploding gas of a gas-engine, uses its power in a cylinder with a piston. This cylinder is a sort of upright tube, in which the piston works with a straight up-and-down movement, and in most cases this straight movement has to be converted into a rotary motion of a crank shaft. A good deal of power is therefore lost; for only at one point, when the crank and connecting rod are at right angles to each other, is the force working to the best advantage. When the crank and the connecting rod are in line with each other at the top or bottom of the latter's throw, no amount of force behind the piston can rotate the crank. This is why the steam-turbine, in which this wasteful transmission of power is avoided, has come largely into use. But though the steam-turbine is a wonderful success, it does not really satisfy the mechanical mind. There is a lack of positive force about it. To rotate a shaft and rotor by blowing high-pressure steam on to innumerable tiny vanes of the rotor seems a method on which some inventor should improve.

It would be preferable to trust to the steady pressure of steam, instead of getting work out of its mere impingement. So it is probable that the steam-turbine will be displaced by a rotary engine. The steam will be used in much the same way as it is in an ordinary steam-engine, but instead of the piston being impelled backwards and forwards along a straight line, it will be driven in a circular movement.

The steady pressure of the steam will be applied direct to a piston attached to the crank shaft, and the piston will work in a new kind of cylinder that gives it a circular path instead of a straight path. In this way the power will be applied directly and cheaply. Some rotary steam-engines of this kind have been constructed in recent times, and shown working apparently well, but none of them seems yet to have been developed into a practical success. In all probability the new kind of piston with a rotary path will first come into practical use in some explosive engine using petrol, alcohol, or other spirit. But it may be twenty years before the rotary engine comes into general use, and perhaps it will be longer before the steam-engine with a direct circular movement appears as a rival to the steam-turbine.

A continuous circular movement is required in such things as valve mechanism, instead of the reciprocating movement that is still employed. Not only would the main parts of the engine be improved by a direct rotary motion, but the smaller mechanisms would be more effective if they were constructed on the rotary principle. Some engineers, indeed, think that reciprocating movements on machinery may practically disappear in the next quarter of the century. If this is so, there is a fine opportunity for men with a mechanical turn of mind and inventive talent to work out the details of this feature of the rotary mechanism of the future.

Still more important is the problem of using the heat from coal in a more economical manner for the production of steam power and gas power. For many years inventors have been trying to design an efficient internal combustion steam-engine. Instead of putting a kettle on a fire, they want to put the fire inside the kettle and surround it with water, so that none of the heat will be wasted. Several inventors have constructed internal combustion steam-engines, but none of these has been efficient in actual use. And the general

opinion now is that an engine of this kind is almost an impossibility. On the other hand, the recent invention of a new way of producing great heat by burning a mixture of gas and air on the surface of hard rock promises to be of high practical value in a new steam-engine.

But the progress of the gas-engine is likely to make steam power an antiquated source of working energy. It is probable that all steam-engines will be thrown on the scrap-heap in less than a hundred years. In the nearer future—say, from five to twenty years—we shall very likely see coal used in internal combustion engines in a direct manner, without the intervention of a large gas-making plant. The heat of the coal will be converted into work in the engine itself, and no boiler or gas-producer will be required.

Dr. Archibald Low's engine is a very interesting example of this new coal-using explosive engine. The part accommodating the coal is hardly any larger than the ordinary vapouriser on an oil-engine, and, instead of the coal being burnt to produce steam, it is converted into gas in the engine and then exploded in the cylinder. The task before the inventor in regard to this new kind of gas-engine, and in regard to all other engines using explosive mixtures, is to find a means of fully controlling the explosive forces. We require to make the explosions in the cylinder take place at what rate we choose. After all, explosion is only an exceedingly rapid burning of fuel, with, consequently, an exceedingly swift expansion of gases.

Why, however, should we not burn our fuel at what rate we choose, instead of using it in a costly, troublesome, swift manner, when we want only a slow, steady combustion ? In the Diesel engine this much-desired control of the rate of combustion has been to some extent obtained, and there can be but little doubt that sooner or later the gas-engine will be improved in the same way as the oil-engine is being perfected ; and we shall get the combustion and expansion of the gases so modified that gas power will be made to do better work, and some of the excessive waste of heat will be avoided. Now much of the heat of the too rapid explosion is not merely a waste, but a nuisance. To prevent damage, cold water has to be circulated over the heated parts. We shall, however, have to wait many years before the slow-combustion gas-engine, using coal in a direct manner, is developed into a general source of power. At the present time the problem of the four-stroke and the two-stroke explosive engine is engaging the immediate attention of engineers. In nearly all motor-car engines, and indeed in most oil and gas engines, the work is done on the four-stroke principle. In four-stroke engines a working explosion occurs in the cylinder only once in every four strokes of the piston. Thus the working impulses are comparatively far apart, and at slow speeds this tends to cause uneven running, especially if only a single cylinder is used. That is the reason why most motor-car engines have at least four cylinders. Everything goes to show, however, that in the next five or six years the type of engine will be modified, so that each cylinder will give a working stroke at every revolution of the crank shaft. The principle has already been applied to many motor-cycles, for the two-stroke type of engine gives smoother running,

Later, the motor-car may use two of its wheels, and run only on two large tyres with more safety than is now afforded by four wheels. For the balancing action of the gyroscope, which Mr. Louis Brennan has for some years been using on his mono-rail, has recently been employed with success on a two-wheeled motor-car in London. Possibly all cars, in from twenty to fifty years' time, may be single-track, two-wheelers with large tyres. And by the time this is accomplished a new type of railway will be in general use. Whether it will be some form of mono-rail, or a train suspended a few inches in the air and propelled like a flying machine by a propeller, is a matter of doubt.

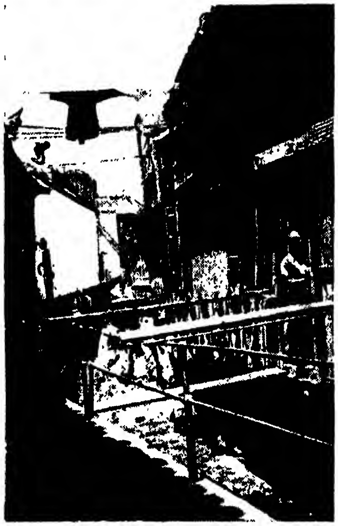
The toy flying train that M. Emile Bachelet has brought to England has excited the popular imagination, but it has yet to be proved that the cost of working such a train with full-sized passenger-cars, and of driving it against a gigantic wind-pressure, is not prohibitive.

M. Bachelet lifts his train up by means of repulsive magnets, placed at short intervals along the track, and the cost of making these numerous magnets, keeping them in thorough repair, and supplying them with electricity may be far greater than the cost of running a mono-rail train with its easily worked gyroscopes.

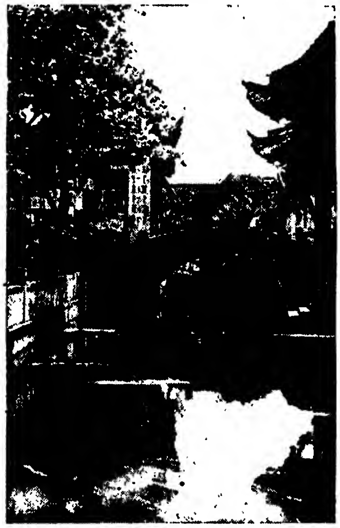
EDWARD WRIGHT

FIVE PICTURESQUE CORNERS OF CHINA

A MARKET IN THE NATIVE CITY, SHANGHAI

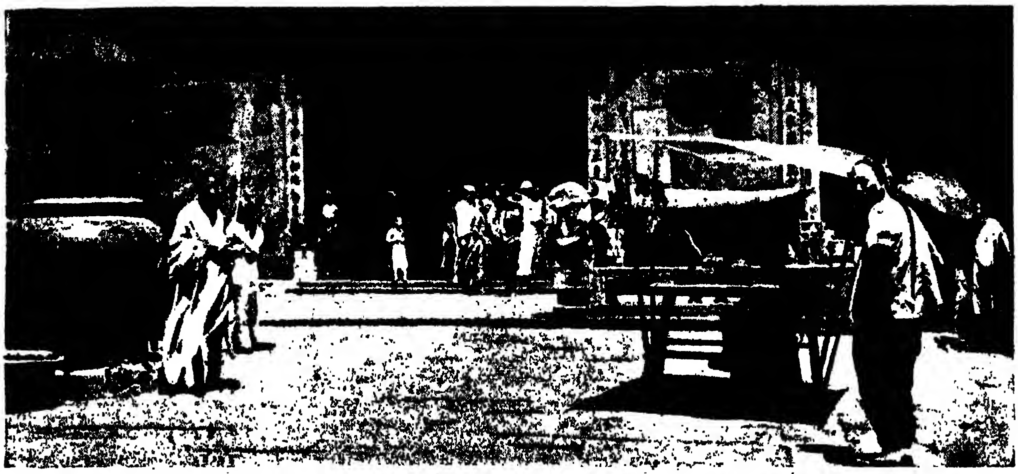


A SHOP ON A DRAIN



AN OVAL BRIDGE

THE SHADIEST STREET



A JOSS-HOUSE AND INCENSE-BOWL IN A COURTYARD 700 YEARS OLD

Climate, River Basins, Products, and Towns of China. Manchuria and Mongolia. Turkestan and Tibet.

THE CHINESE EMPIRE

THE Chinese Empire (4,280,0)0 sq. miles) consisted of China proper and of Manchuria, Mongolia, Turkestan, and Tibet; but Russia is encroaching on Mongolia, which has become independent, and in Northern Manchuria, while Japan controls Southern Manchuria. At present, China is governed by a dictator.

China. This country lies on the eastern slope of the Central Asian highland region, and includes the fertile alluvial lands made by the rivers which drain these highlands east to the Pacific. The largest are the Hwang-ho in North China, the Yang-tse-kiang in Central China, and the Si-kiang in South China. The western provinces are mountainous, but eastern China consists in large part of the fertile lowlands of these and smaller rivers.

Climate. Peking, the capital of China, situated near its northern limit, is in the latitude of Southern Italy. Its mean annual temperature is that of London, though its summers are much hotter and its winters much colder. The winter climate of the northern half of China is made severe by the prevailing north-west winds from the highlands of Central Asia. The northern rivers are frozen in winter, and even Shanghai, in the latitude of Tripoli and Jerusalem, has severe winter frosts. The climate of Southern China, which is crossed by the Tropic of Cancer, is tropical.

China lies in the monsoon region, and the consequent regularity of the seasons early made agriculture important. The Chinese regard this as the most honourable of human occupations, and wisely so, for the prosperity of their teeming population depends wholly on the patient and laborious cultivation in which the Chinese excel. The crops raised are very various. In Northern China wheat and millet—one species taller than a man—are the cereals. Rice is not grown north of the Tsingling Mountains, which separate the Hwang-ho and Yang-tse basins. Central China produces rice, tea, cotton, silk, and opium. Sugar, indigo, and spices are grown in the tropical provinces of South China.

Many Chinese trees—the oak, maple, poplar—we know, but others—the useful wax, tallow, soap, and varnish trees—are unfamiliar. The beauty of the azaleas and other flowering shrubs explains its title of the Flowery Land.

The Yellow Lands of North China. The yellow or loess lands of North China are indescribably fertile. All that they require is a little fresh sprinkling of their own loam on the surface, and they bear crop after crop with undiminished fertility. The origin of this fertile soil is very interesting. In the course of many ages the winter gales have swept it down as fine sand from the mountains and deserts of Central Asia, filling up the hollows and valleys of the old land surface, and gradually levelling it. In the process layer after layer of grass and other vegetation has been steadily but imperceptibly buried. The decay of this has added fertilising substances to the soil, which has been rendered still more light and porous by the disappearance of the buried plants. Water sinks easily through such ground, dissolving the chemical substances present, and forming a kind of natural liquid manure.

A Strange Country. This fertile yellow soil has certain disadvantages. The rivers cut their channels deeper and deeper through the loose soil, and flow between lofty banks far below the surface level. Similarly, the roads sink deeper and deeper below the surface, forming at last mere cracks 8 ft. or 10 ft. broad, winding between walls of perhaps 100 ft. high. Seen from above, the country seems to be densely cultivated, but uninhabited, for the dwellings are out of sight along the invisible roads. Irrigation would obviously be impossible, but, fortunately, the rain is ample for cultivation.

The Hwang-ho Basin of North China. The Hwang-ho, or Yellow River, rises in the Kwenlun Mountains, and cuts its way down in gorges easier to imagine than to describe. It makes a great bend along the base of the Alashan, and turns south through mountain defiles between the Chinese provinces Shensi and Shansi. The Wei comes in from the mountains of Kansu province, which extends far into the Central Asian highlands. In its lower fertile plain is Singan, estimated to have a million inhabitants. The main stream takes the direction of the Wei, and flows due east along the northern base of the Tsingling Mountains, draining the lowlands of Pechili and Honan, between which the mountainous peninsula of Shantung, with the foreign settlements of Wei-hai-wei, and Kwei-chou, juts out into the Yellow Sea. Wheat and millet are the staple crop—a diet which makes the Northern Chinaman taller and hardier than the men of the rice-eating provinces. The province of Shansi is destined to become the Pennsylvania of China. Inexhaustible deposits of coal and iron occur together, and the mountain rivers provide unlimited power for electrical and other industries, as well as for transport.

China's Sorrow. The lower course of the Hwang-ho is over alluvial lands built up by the river itself. To prevent it from overflowing its banks when swollen by the melting snows of the lofty mountains of Central Asia, the river is embanked. This restrains it for a time, but in

the end the river triumphs. The sediment it carries must be deposited somewhere; and if embankments prevent it from spreading this out over the surrounding land, it must drop it on its own bed, the level of which is consequently always rising. As it rises, the embankments rise, too, and thus the river is at last far above the level of the surrounding country. "The dykes grow from mere walls into ranges of earthworks, like fortress sides, hundreds of miles long, and the effort overtaxes the skill of the engineer and the perseverance even of Chinese labourers. When the Yellow River, gorged with water from the mountains till it forms a gigantic reservoir averaging a mile broad, from 300 to 500 miles long, and 70 ft. deep, all suspended in the air by artificial supports, comes rushing down in autumn, the slightest weakness in these supports is fatal." A tiny crack grows into a leak, the leak into a rent, the rent into a great breach, and the whole volume of water pours down with immeasurable momentum over the populous plain below.

"The torrent, in its first and grandest rush, though throwing out rivers every moment at every incline of the land, had for its centre a stream 30 miles broad and 10 ft. deep, travelling at 20 miles an hour." For two months the Hwang-Ho poured over the plains, none reaching the sea, and it is estimated that 7,000,000 persons perished. At last the water began to reach the sea, the great lake shrank to a river, and the Hwang-ho had a new course. When this happens, embanking begins again, the new bed gradually rises into the air as did the old one, and in a generation or two the calamity repeats itself. For many centuries the Hwang-ho has been China's sorrow."

Peking. North of the Hwang-ho is Pechili, drained by the Pei-ho. Here the capital, Peking, with 1,300,000 inhabitants, is built in a sandy plain, not far from the southern mountains of Mongolia. It is a double city, Chinese and Tatar, both massively walled. Within the Tatar city is the Imperial City, and within that, again, the Forbidden City, once the Imperial residence, and now the seat of the republican government. "With its broad streets and vast, open spaces, Peking is more Central Asian than Chinese in character, and its unpaved streets are thronged by files of camels, bringing coal, wood, and other produce into the city." It is rapidly being transformed, and is becoming a great railway centre. Tientsin, on the Pei-ho, is the port of Peking, and has about a million people.

The Yang-tse Basin of Central China. The Yang-tse (3200 miles) rises in Tibet, its upper course being through mountain defiles in little-known country. It enters China between the provinces of Sechwan and Yunnan, both mountainous, and its course across the former province is through gorges of great beauty, but extremely difficult of navigation.

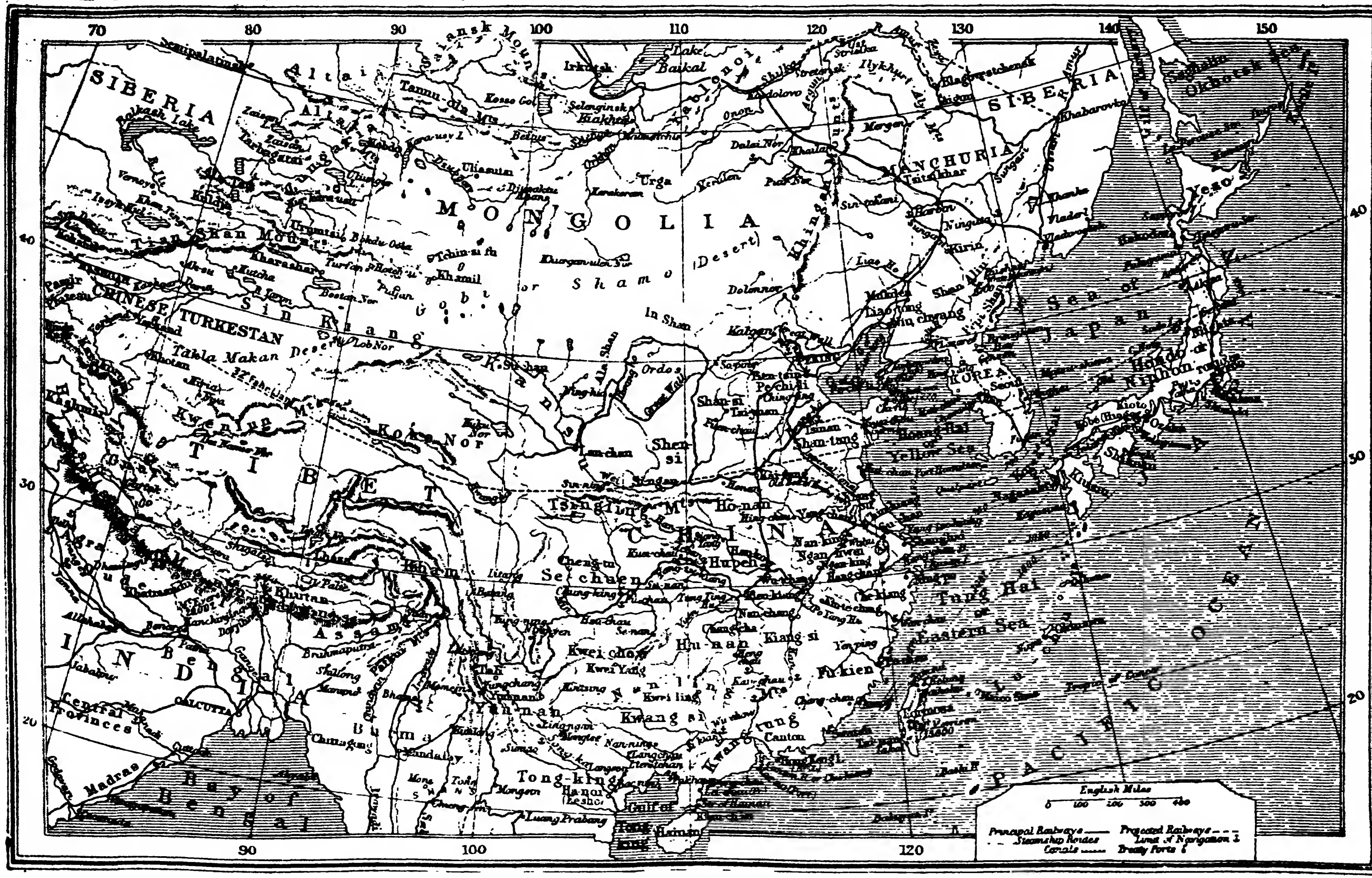
The Red Lands of the Yang-tse. The red sandstone lands of the Yang-tse almost vie in fertility with the yellow lands of North China. Moisture is abundant, and the hills are terraced for cultivation from base to summit. Sechwan is the richest and most tropical province of Central China, producing tea, rice, silk, opium, rhubarb, and other drugs, varnish, soap, wax, tallow trees, coal, iron, salt, and other minerals. Chungking, built on heights where the Kialing comes in from the north, is the commercial capital of the province.

The Min Valley. The Min is remarkable for the masterly irrigation works which have converted the Chengtu plain (2800 sq. miles), one of the few level areas of Sechwan, into the most highly cultivated and densely populated area of its size in the world. "We see innumerable water channels lined with trees, chiefly poplars, and farmhouses and residences so thickly stud the plain that they appear almost continuous. Numerous fine temples and well-endowed monasteries surrounded by groves of tall forest trees and bamboo thickets are constantly in evidence, and the whole plain and the surrounding hills afford a pleasing contrast to the tree-denuded slopes so common throughout China."

The Lower Yang-tse. At Ichang the Yang-tse leaves its famous gorges. In the remaining 960 miles of its course, though it has some hills to pass through, it falls only 130 ft. Rich alluvial plains, once perhaps old lake basins, extend on either side, and are often flooded. Hankow, at the confluence of the Han, the river of the province of Hupeh, which produces cattle and hides, is the centre of water and railway communications. With a million inhabitants, it is destined to grow rapidly and to be the Chicago of China. Every kind of produce from the vast basin of the Yang-tse is brought to its markets, and new industries and factories are constantly coming into existence. Much timber is floated down to the Yang-tse by tributaries from the mountainous province of Hunan, to the south, where much tea is grown. Kiangsi has similar products. Nganhwei grows excellent green tea, and contains some of the richest rice-lands in China. Kiangsu, the delta province of the Yang-tse, is a Chinese Holland, with innumerable canals and reclaimed meadows lying below sea level. The capital is Nanking. The delta is steadily growing seawards, and in a century or so Shanghai, the port of the Yang-tse, on a river connected with the delta, will be above tidal influence. In a geographical sense it is the New Orleans of China, but in importance it compares better with New York, as it is the commercial metropolis of China. It owes its prosperity to the wealth of the Yang-tse basin, which will increase enormously when its mineral resources are systematically exploited.

Southern China. Between the basins of the Yang-tse and the Si-kiang, the great river of Southern China, are Che-kiang and Fukien, resembling the Yang-tse provinces in climate and products. Che-kiang has been called a miniature Sechwan, with lower hills forested or cultivated to the summit. The chief port, Ningpo, in a rich rice-growing plain, surrounded by mountains, has flourishing cotton-mills.

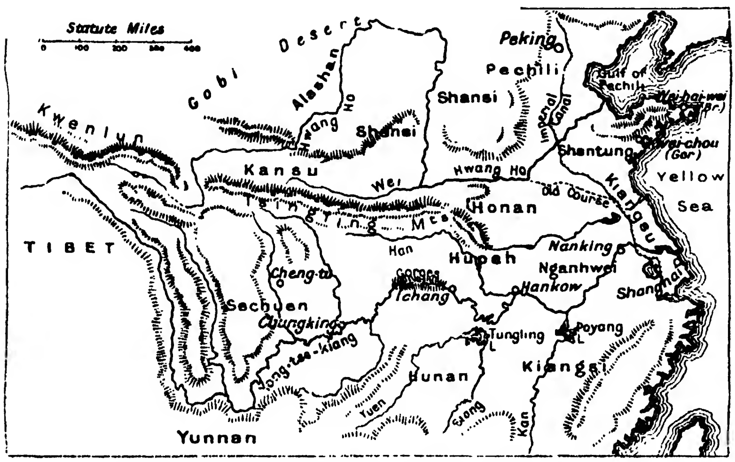
THE MOST THICKLY AND MOST THINLY PEOPLED REGIONS OF THE HABITABLE WORLD



THE CHINESE EMPIRE AND THE SURROUNDING COUNTRIES

Hangchow is an old capital of China. Fukien, also mountainous, produces the finest tea, shipped from Fuchow. Amoy, with a fine harbour, does an immense trade in tea.

The Si-Kiang Basin. The Si rises in the Yunnan Mountains, cutting its way down in gorges and ravines. Together with its two tributaries it drains the three chief valleys of Southern China, which converge on Wuchow, now a treaty port. All the Si basin, which includes part of Yunnan and Kweichow and all Kwangsi and Kwangtung, is mountainous, forming part of the great descent from the Tibetan plateau. Along the river bottoms and in the fertile plains are grown the usual Central China crops, with others of a tropical character.



THE BASINS OF THE HWANG-HO AND YANG-TSE-KIANG

The ports of Kwangsi produce cinnamon, mace, and other spices. Sugar and indigo and other tropical produce are grown in the fertile maritime province of Kwangtung. Canton, also with a million people, is the commercial centre of Southern China. The neighbouring island of Hong Kong is an important pivot of British influence in the Far East.

Manchuria. Manchuria (365,000 sq. miles) is a steppe land backed by mountains. It is drained by the Amur and its tributary the Sungari. The climate is extreme. Its hot summers, monsoon summer rains, and rich black loam make it one of the granaries of the world. Harbin, on the Sungari, mills 1,000,000 lb. of flour a day. The surrounding region is one vast wheatfield. Southern Manchuria is drained by the Liao-ho. The capital is Mukden. The port of Manchuria is Niuchwang. As Manchuria is rich in minerals, furs, and timbers from its forests, Niuchwang is rapidly becoming very important. Port Arthur, formerly Russian, is now Japanese.

Mongolia. The plateau of Mongolia (1,100,000 sq. miles) has an elevation of 3000 or 4000 ft. with mountains rising much higher. In the east the Khingan Mountains separate it from Manchuria, intercepting the moist Pacific winds which make Manchuria so fertile. The western margin is formed by the Altai Mountains. Shut off by mountains from moist winds, remote from the sea, and lying high, Mongolia has a dry and extreme climate. The waterless desert of Gobi in the centre of the plateau occupies about a quarter of its area. The rest is steppe, rich or poor according to locality, supporting a scanty population of Mongolian herdsmen and their camels, horses, and sheep. The most fertile part lies north of Kalgan, in Pechili, the gate of Mongolia, and extends along the northern margin, which is followed by the high-road to Kiakhta, Urga, and Siberia.

Turkestan. This includes the rest of Chinese Central Asia (550,000 sq. miles) outside Tibet. Turkestan is crossed by the lofty Tian-shan Mountains, separating Zungaria and the Ili basin in the north from Kashgara and the Tarim basin in the south. An explorer has admirably described the region: "If you could get a bird's-eye view of Turkestan you would see a great, bare desert, surrounded on three sides by barren mountains. At their bases you would see vivid green spots showing out sharp and distinct like blots of green on a sepia picture." In the western end round Kashgar and Yarkand the cultivation is of greater extent, and more continuous than in the eastern half, where the oases are small and separated from each other by 15 or 20 miles of desert. Both the towns named, and Khotan, further east, are on tributaries of the Tarim. The most important oasis of Zungaria is Kuldja on the Ili, which flows to Lake Balkash.

Tibet. The plateau of Tibet (740,000 sq. miles) varies in elevation from 9000 to 17,000 ft., the mountains rising some thousands of feet higher. It is enclosed between the Kwenluns and Himalayas, connected in the west with the Pamirs. In the east a series of little-known ranges, separated by the ravines of the Chinese and Indo-Chinese rivers, form steps in the descent to the Pacific.

Northern Tibet is a desolate region crossed by parallel chains of lofty mountains, inhabited only in the height of summer, when wandering herdsmen drive their yaks to the mountain pastures. Settlement is confined to the south, chiefly to the Brahmaputra and its tributary valleys, where barley, peas, and even some stone fruits ripen. The winters are frightful in their inclemency. The keeping of yaks is the chief means of livelihood. The capital is Lhasa, long a forbidden city to Europeans, but occupied by the British in 1904.

A. J. AND F. D. HERBERTSON

Cone and Cylinder. Triangular Prism. Square, Hexagonal and Octagonal Pyramids. Regular Polygons. Circle and Tangents.

MODEL DRAWING AND GEOMETRY

In this part we shall explain how to draw conical and cylindrical shaped objects. It is necessary that great attention should be given to the very important principles underlying the representation of the many thousands of such curved objects. More errors are made by beginners in drawing them than perhaps in drawing any other shapes.

The different appearances of a circle have already been explained [see **17**], so now let us take a simple cone as our model. This object, like all others, may have an infinite number of apparent shapes, some of which are shown in **139–144**. To understand the fundamental principles of drawing such an object, let us imagine there is a line, called *the axis of the object*, passing through the middle of the cone from the apex to the centre of the base [AB in **139**], and another line, CD, called *the major axis of the ellipse*, along the surface of the base. It will be noticed that these two lines are at *right angles* to each other, and they *always* appear so, no matter in what position the cone may be placed. [See **139–144**.] From this we deduce the following very important rule: *The major axis of the ellipse always appears to be at right angles to the axis of the object.* This rule holds good not only for the cone but for the cylinder and all other similar shaped objects, such as tumblers, flower-pots, pails, jars, bottles, vases, barrels, etc. [See **145–160**.]

The Cone. It is sometimes difficult to see that this is so, but the student must endeavour to train his eye to see this fact by careful observation and comparison. It is essential to remember it as carefully as the rule that receding parallel lines appear to converge. A great help at this stage would be to get a cone (or, if this be unavailable, a large funnel would do), place it in such positions as indicated in **139–144**, and endeavour to see that the rule holds good *always*.

Fig. **139** is a view of the cone when standing upright with its base below the eye level, but **140** is the appearance when the base AB is level with the eye. Here, again, the outline alone does not represent the roundness of the cone, but if it were shaded, as was done in **30**, it would appear round. Fig. **141** is a view of the cone lying down, with its apex turned away from the spectator, while **142** is the apparent shape when the apex is towards him.

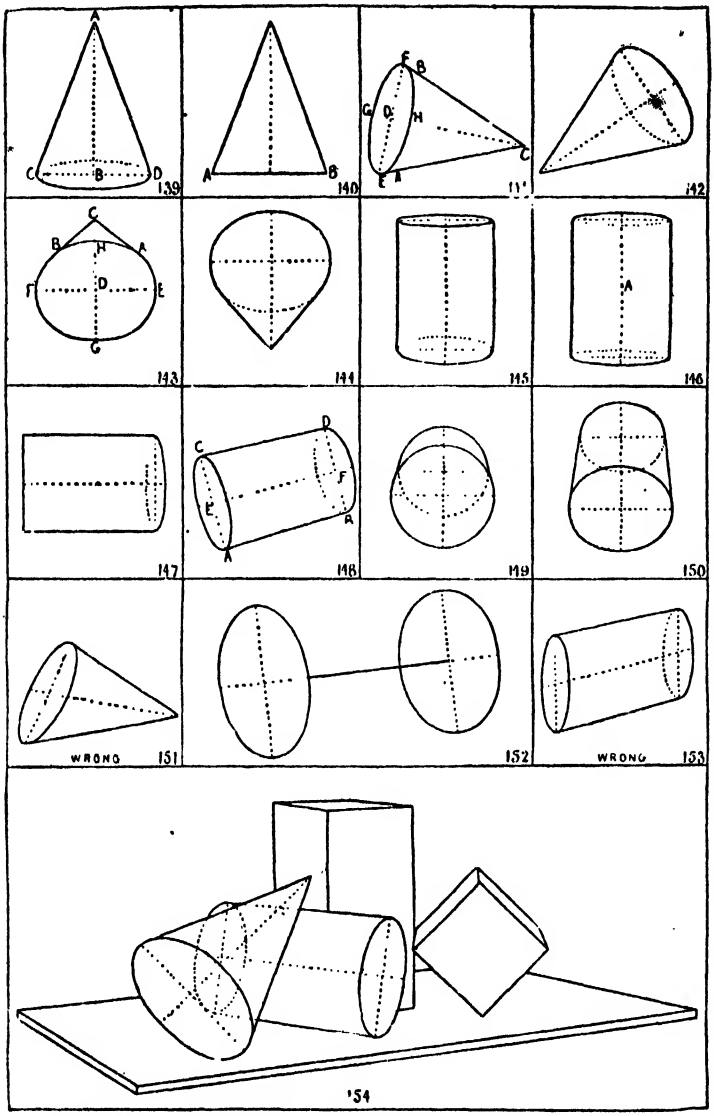
Fig. **143** shows the appearance when the cone is tilted with the edge of the base resting on a horizontal plane, and the apex raised and turned away from the observer. Notice how very much the length is foreshortened. Fig. **144** shows the cone lying down on a horizontal plane, with its apex pointing directly towards the student. In **142** and **144**, although the base is turned away from view, yet we see more than half the ellipse.

It is generally best to commence drawing the cone by sketching the straight lines CA, CB in **141** and **143**, noting carefully the slant of each; then draw the axis CD of the object, which bisects the angle BCA, next determine the position of the point D, by observing what the apparent length of CD is, and afterwards draw through D the major axis EF of the ellipse *perpendicular* to CD, comparing its length with CD. Then obtain the apparent length of the minor axis GH, thus obtaining the four points F, H, E, G, through which the ellipse should be drawn. It must be noticed that CA, CB do not necessarily intersect the ends of the major axis at E and F, but they are *always tangents to the curve of the ellipse*.

The Cylinder. After all this explanation concerning the cone, the drawing of the cylinder should not give a great deal of trouble. It will be seen in **145–150** that in every case the major axes of the ellipses are perpendicular to the axis of the object. But there is another very important observation to be made, and that is: the ellipses at each end are not exactly of the same shape. With an opaque object this difference is difficult to realise; but if the student makes a study of an object like that represented in **152** (which is constructed of two circular and equal pieces of stiff cardboard, with their centres joined by a piece of wood or stiff wire, so that the circles are kept rigidly parallel to each other, and perpendicular to the wood or wire), he will easily be convinced, by measuring with the eye and a pencil, that the further ellipse is *apparently rounder*, or more like a circle, than the nearer one is; the major axis of the further ellipse is a little shorter than that of the nearer one, while the minor axis of the further ellipse is (within limits) longer than that of the nearer one.

Begin to draw the cylinder by sketching the straight lines AB and CD [see **148**], and, before doing so, three facts must be observed: First, what slant AB and CD make with the surrounding objects; secondly, what distance apart they must be in order to obtain the correct relative thickness of the cylinder; and, thirdly, the right amount of convergence, since they recede. Next draw the axis EF, and afterwards proceed as with the cone, but bearing in mind the apparent different shapes of the ellipses. The straight lines which are part of the drawing of the cone or cylinder do not represent *edges*, but the boundary between the visible and the invisible portion of the curved surface of each object. This well illustrates how conventional *outline* drawing is.

Fig. **145** is the appearance of the cylinder in a vertical position below the eye level. Notice the different distances from front to back of the top and bottom ellipses. Fig. **146** shows the view when upright, but the eye directly opposite point A. Fig. **147** is the representation when the cylinder is lying on a horizontal plane, and the eye is directly opposite the left-hand edge. Fig. **148** gives the appearance when the object is lying in a horizontal plane but slanting away from the observer. Fig. **149** is an end view with the length very much foreshortened. Fig. **150**, when resting on one edge, and the further end tilted up away from the student. In **151** is shown a very common error in drawing the cone when in the position shown in **141**. It



139–154. A LESSON IN DRAWING THE CONE AND CYLINDER

should be noticed that in **151** the major axis of the ellipse is not at right angles to the axis of the object, as it ought to be. Fig. **153** is an incorrect drawing of the cylinder, and shows two common mistakes, viz., the major axes of the ellipses are not perpendicular to the axis of the object, and the further ellipse is not wide enough. Fig. **153** ought to be drawn as in **148**. In the wrong drawing [**153**] the major axes are vertical, and students may at first think that they ought to be so, because the ends of the cylinder are really vertical planes; *but it does not follow that, because the ends are vertical, the apparent longest axis of the ellipse is vertical.* The student will see that the *apparent longest direction* of the ellipse is *slanting*, as shown in **148**.

Useful Exercises. Good exercises at this stage would be to make studies of groups as shown in **154**, and give most careful and searching observation to the proportion and perspective of the objects, in order to still further improve the power of *seeing correctly. Do not forget the spaces.*

By this time the student ought to have made such progress in drawing rectangular, conical, or cylindrical objects to be found among household utensils, and so forth—such, for instance, as **155–160**—as to enable him to draw from much larger objects. It will help him if we discuss certain principles underlying the drawing of the triangular prism, square and polygonal pyramids.

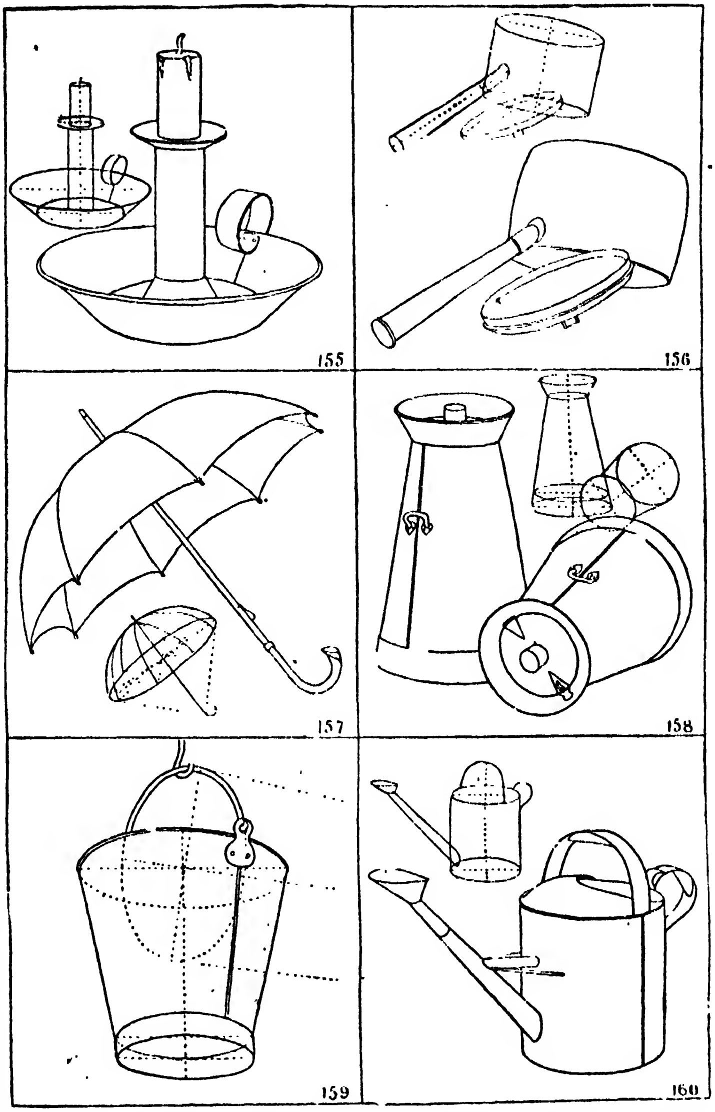
Several different views are shown in **161** to **166** of a prism which has an equilateral triangle at each end. The student should obtain one or two such prisms, or make them out of bits of cardboard, fastened at the edges by means of tape or paper. A convenient size would be about 12 in. or 15 in. long, and edges of the triangular ends about 7 in. or 8 in. Place the prisms in such positions as indicated in **161** to **166**, and study *the apparent changes* in the form of the equilateral triangle, the foreshortening, in some views, of the long edges, and the direction of the apparent convergence of certain parallel edges. It is of little use to examine only the representations given in **161–166**; the student *must train his eye to see correctly* the many apparent forms which an object takes.

It will be seen that when the prism is lying flat down on one of its oblong faces the apex A (although really vertically over the *real* centre D of the base BC) is only apparently so when the student is directly opposite the end, as in **162**. In **161**, **163**, and **165** the apex A is apparently vertically over the point D, which is not the *apparent* centre of the base BC, for the nearer *real* half CD in **161** and **163** is apparently slightly longer than the further *real* half BD, and in **165** BD is greater than DC. In **166** the apex A is vertically under the point D, as the prism is supposed to be resting on an edge, with its upper oblong surface parallel to the ground. Beginners often make an incorrect drawing like that in **167**, because they do not see the correct apparent position of the apex A with reference to the base BC. Of course, when the object is tilted, as in **161** and **165**, the apex A does not necessarily appear vertically above the point D of the base BC; when the prism is in such positions the apex may appear to be in an infinite number of places not vertically over D; and to determine these relative positions careful observation of the object must be

made. It should also be noticed how varied are the *apparent* lengths of the edges of the equilateral triangle and of the long edges of the prism. In **163** the student should observe that the base *BC* of the further end is apparently slightly longer than *BC* of the nearer end; this is only another example of what was mentioned concerning the further end of the cylinder [see **152**]. Great attention should be given to the *direction* of apparently converging edges, although no errors should be made if the student remembers that receding parallel edges always appear to converge in the direction they *go from* him, whether upwards or downwards from him, or right and left away from him.

The Square and Other Pyramids. We will next examine the square pyramid, of which several correct representations are given in **168–175,** but **176** is incorrect, and shows a very common error made by beginners, who forget, or do not observe, that, when the object is standing on its base, the axis *AB* of the pyramid ought to be *vertical,* and therefore also the apex *A vertically* over the centre *B* of the base, as in **168, 169,** and **175.** The triangular faces of the pyramid vary infinitely in their apparent forms, especially when the object is lying down on a triangular face, or when tilted as in **170–174**; and to obtain a true drawing the student must exercise his perceptive powers most carefully. In **175** we have a view of the pyramid with its axis vertical, and the object above the eye level; this shows how a spire or turret might appear on a building. Some spires and turrets are similar in construction to a hexagonal or octagonal pyramid, as shown in **177** and **178,** which are all representations of vertical positions of these pyramids, **177** and **181** being the appearance when below the eye level, **178** when the base is just on the eye level, and **179, 180,** and **182** when above the level of the eye. In all of these [**177–182**] it will be seen that the axis *AB* and the apex *A* are again vertically above the centre *B* of the base. The position of this centre may be easily found by drawing diagonal lines, as indicated by dotted lines on the bases of **177–182.**

The student should now be prepared to make studies of objects such as **183–185.**



155–160. OBJECTS DRAWN ON SAME PRINCIPLE AS CONE AND CYLINDER

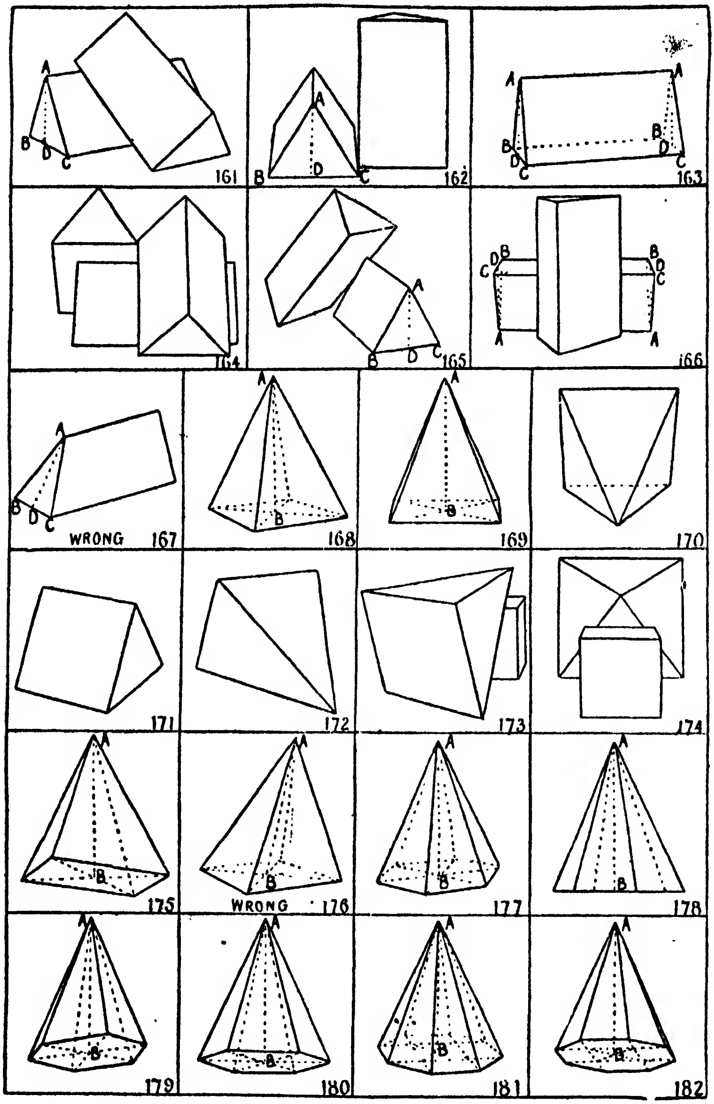
PRACTICAL GEOMETRY

Regular Polygons. There are general and special methods of constructing these polygons. The general methods, as in **187, 188,** and **193–195,** apply equally to all polygons, but in particular polygons the special method is sometimes shorter and more accurate, as in **189–191,** and **196–198.** Remember the following important facts concerning *regular* polygons.

i. Lines which bisect the angles of regular polygons meet in one point, which is the centre of the figure, and they divide the polygon into a number of equal triangles. In the hexagon these are equilateral [**189**], but in all other regular polygons they are isosceles [**191–192**].

ii. The centre of the polygon is the same as that of the circle to which the sides of the polygon are tangent (the *inscribed* circle) and also of the *circumscribed* circle which passes through the angular points [see **187–194**].

iii. The sum of all the interior angles of a regular polygon plus four right angles is equal to twice as many right angles as the figure has sides



161–182. THE TRIANGULAR PRISM: SQUARE, HEXAGONAL, AND OCTAGONAL PYRAMIDS

[Euc. I., 32.] This affords a ready method of constructing any regular polygon by means of the protractor, as in **195**, when the side is given—a fact made use of in surveying.

187. In a Given Circle, to Inscribe any Regular Polygon (Approximate Method). Draw the diameter AB and divide it into the same number of equal parts as the figure has sides (say, five). With A and B as centres, and AB as radius, make arcs intersecting at C. From C draw CD, *always through the second division on* AB, cutting the circle in D. Join AD, which is one side of the pentagon required. Set off AD round circle and join points as shown.

188. Another Method. Draw any radius AB. At the centre A make an angle with AB equal to 360° divided by the number of sides of the regular polygon required; say, a pentagon. Thus, $360° \div 5 = 72°$. Therefore, make the angle $BAC = 72°$. Join BC, which is one side of the pentagon. Set off BC round the circle, and join the points as shown.

189. To Inscribe a Regular Hexagon in a Given Circle (Special Method). Drawn any diameter AB. With centres A and B, and radius equal to that of the circle, cut the circle in 1, 2, 3, and 4. Join the points as shown.

190. To Inscribe a Regular Duodecagon in a Given Circle (Special Method). Draw two diameters AB and CD perpendicular to each other. With centres A, B, C, and D, and radius equal to that of the circle, describe arcs cutting the circumference of the circle. Join the twelve points as shown.

191. To Inscribe a Regular Octagon in a Given Circle (Special Method). Draw two diameters AB and CD as in **190**. Bisect each quadrant thus formed, cutting the circumference as shown. Join the eight points thus obtained.

192. To Describe any Regular Polygon About a Given Circle (General Method). Divide the circumference into as many equal parts as the figure is to have sides (say, five for a pentagon). From the centre C draw lines through each point. Draw AB, one of the sides of the inscribed pentagon. Bisect AB by the perpendicular CD, cutting the circumference in D. Through D draw the tangent EF parallel to AB, cutting CE in E, and CF in F. Make CG, CH, and CK each equal to CE or CF. Join F, G, H, K, and E as shown.

193. On a Given Line AB to Construct any Regular Polygon (General Method). Produce AB, and with centre B and radius BA describe a semicircle, and divide it into the same number of equal parts as the figure has sides (say, five). Join B with 2. Bisect AB and $B2$ by lines intersecting at D. With D as centre and radius DA or DB, or $D2$, describe a circle. Set off AF and FE each equal to AB. Join the points thus obtained.

Note. In this construction great care is required in dividing the semicircle correctly, which may be done with the protractor. As there are 180° in a semi-circle, divide 180° by the number of sides the polygon will have; thus, $180° \div 5 = 36°$. Then make the angle $CB1$ equal to 36°, and mark off $C1$ round the semicircle as shown. The semicircle may be divided into *four* equal parts with the 45° set-square, and into *three* equal parts with the 60° set-square.

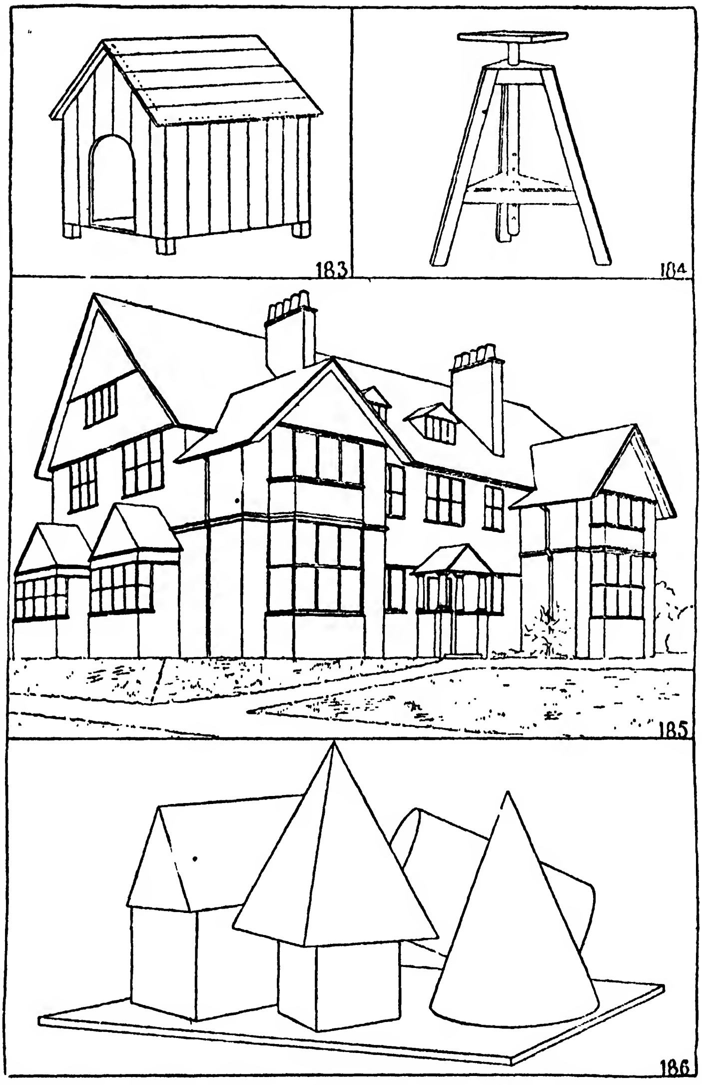
194. Another General Method. Bisect AB by the perpendicular CD. Make CE equal to AC or BC. With centre B and radius BA describe an arc cutting CD in E. E and F are respectively the centres of circles belonging to the square and hexagon. Bisect EF in G. With centre G and GA or GB as radius, describe a circle, and set off AB round it. Join the points, and $ABMNO$ is the pentagon required. By making 6 7, 7 8, 8 9, etc., each equal to 4 5 or 5 6, we obtain centres for the heptagon, octagon, etc., as shown.

195. Another General Method, by Using the Protractor. The number of degrees in each angle of a regular polygon may be found as follows: *From twice as many right angles as the figure has sides, subtract four right angles, and divide the remainder by the number of angles in the figure.* [Paragraph iii.] Suppose a regular pentagon be required. As it has five sides, from *ten* right angles deduct four, and the remainder is six right angles. Then $(90° \times 6) \div 5 = 540° \div 5 = 108°$. At A and B make angles of 108°. Make AE and BC each equal to AB. With E and C as centres and AB as radius make arcs intersecting at D. Join the points as shown. For a nonagon the angle would be found thus: From eighteen right angles deduct four, leaving fourteen right angles. Then $(90° \times 4) \div 9 = 1260° \div 9 = 140°$.

198. To Inscribe an Octagon in a Given Square $ABCD$. Draw the diagonals AC and BD. With centres A, B, C, and D, and radius AE (half the diagonal), describe arcs cutting the sides of the square in F, G, H, K, L, M, N, and O. Join FG, HK, LM, and NO. Then $FGHKLMNO$ is the required octagon.

199. To Construct any Regular Polygon, having the Diameter AB Given. Through A draw CD perpendicular to AB. Take any convenient distance Ac, and make Ad equal to it. Upon cd construct, say, a regular pentagon $cdebf$. From A draw lines through e and f. From B draw BE and BF respectively, parallel to be and bf. And from E and F draw ED and FC parallel to ed and fc. Then $CDEBF$ is the required pentagon.

It should be noted that the diameter divides the polygon into two equal parts. In a polygon with an *equal* number of sides, the diameter passes through the centre, and is terminated at the middle points of two opposite and parallel sides, as DE in **196**; but in a polygon with an *odd* number of sides it passes through the centre from one angle to the middle point of the opposite side, as AB in **199**.



183–186. OBJECTS DRAWN ON SAME PRINCIPLES AS THE TRIANGULAR PRISM

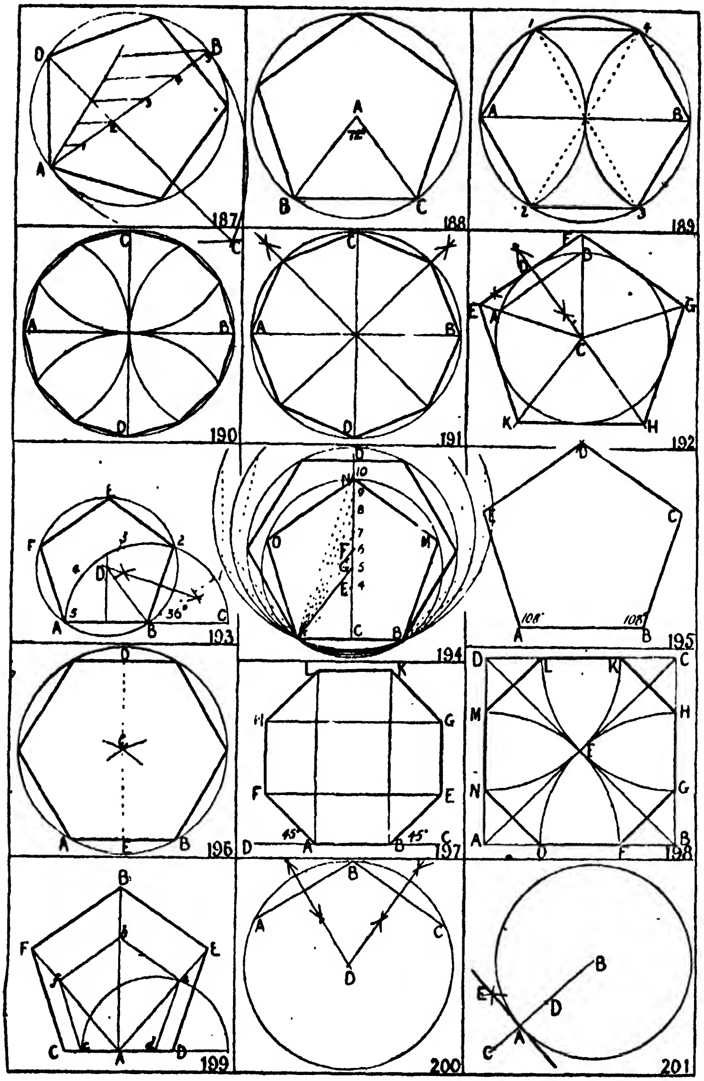
The definitions of a circle, diameter, radius, tangent, etc., have already been given in the Dictionary of Terms Used in Geometry (page 2407), but the following facts should also be known :

i. The circumference of a circle is nearly 3 1-7th, or, more accurately 3·14159, times its diameter. Archimedes discovered that the ratio lies between $\frac{22}{7}$ and $\frac{223}{71}$.

ii. A straight line which bisects a chord of a circle at right angles passes through the centre of the circle. [Euc. III., 1, Corollary.]

iii. The straight line which is drawn at right angles to the diameter of a circle, from its extremity, is a tangent. [Euc. III., 16, Corollary.]

iv. The angle in a semicircle is a right angle. [Euc. III., 31.]



187–201. PRACTICAL GEOMETRY: REGULAR POLYGONS

200. To Describe a Circle Passing Through Three Given Points, *A*, *B*, and *C*. Join *AB* and *BC*. Bisect each by the perpendiculars intersecting at *D*. With *D* as centre, and *DA* or *DB* or *DC* as radius, describe the circle required.

This problem shows how the centre of a circle may be found by assuming any three points in its circumference, how to describe a circle about a given triangle, and how to describe an arc equal to a given arc with the same radius.

201. To Draw a Tangent to a Circle Through a Given Point, *A*, in its Circumference. Find the centre *B* and draw the radius *BA*, and produce it to *C*. Make *AC* equal to *AD* (any convenient distance). With centres *C* and *D*, and any radius, describe arcs intersecting at *E*. Draw *AE*, the required tangent.

202. To Draw a Tangent to a Circle Through a Given Point, *A*, Without it. Find the centre *B* of the circle, draw *BA*, and bisect it in *C*. With *C* as centre, and *CA* as radius, describe a semicircle, cutting the circle in *D*. Draw *AD* the required tangent (Euc. III., 31). By describing a semicircle on the other side of *AB*, another tangent may be drawn.

203. To Draw a Tangent to an Arc from a Given Point, *A*, in it, when the Centre of the Circle is Inaccessible. With *A* as centre and any convenient radius, describe a circle cutting the arc in *B* and *C*. With *B* and *C* as centres and any convenient radius, describe arcs intersecting in *D* and *E*. Draw *DE*. At *A* draw the tangent *AF* perpendicular to *DE*.

204. To Draw Two Tangents to a Circle to Meet at a Given Angle (say, 66°). From the centre *A* draw any straight line *AB*. At any convenient point, *C* in *AB*, make an angle on each side of *AB* equal to *half* the given angle, 66°. From *A* draw *AD* and *AE* perpendicular to *CD* and *CE* respectively, and cutting the circle in F and G. Through *F* and *G* draw *FH* parallel to *CD*, and *GH* parallel to *CE*.

205. To Draw a Tangent Common to Two Equal Circles. First, for *exterior* tangent. Join the centres *A* and *B*. At *A* and *B* erect perpendiculars *AC* and *BD* to the line *AB*. Draw the tangent through *C* and *D*.

Second, for *interior* tangent. Bisect *AB* in *E*. Upon *AE* describe a semicircle, cutting one circle in *F*. Join *AF*, and through *B* draw *BG* parallel to *AF*. Draw the tangent through *FG*. Another interior and exterior tangent may be drawn, as indicated by dotted lines in **205**.

206. To Draw an Exterior Tangent to Two Unequal Circles. Join the centres *A* and *B*, and upon *AB* describe a semicircle. Mark off *DE* equal to *AC*. With *B* as centre, and radius *BE* (the *difference* of the radii of the given circles), describe an arc cutting the semicircle in *F*. Through *F* draw *BG*, and through *A* draw *AH* parallel to *BG*. Draw the tangent *HG* through *H* and *G*.

207. To Draw an Interior Tangent to Two Unequal Circles. Join the centres *A* and *B*, and describe a semicircle upon *AB*. Mark off *ED* equal to the radius *AF* of the small circle. With centre *B* and radius *BD* (the *sum* of the radii of the two given circles), describe an arc to cut the semicircle in *G*. Draw *BG*, cutting the large circle's circumference in *H*, and through *A* draw *AK* (on the other side of *AB*) parallel to *BG*. Through *HK* draw the tangent required. Another could be drawn in this and problem **206** if the semicircle is described

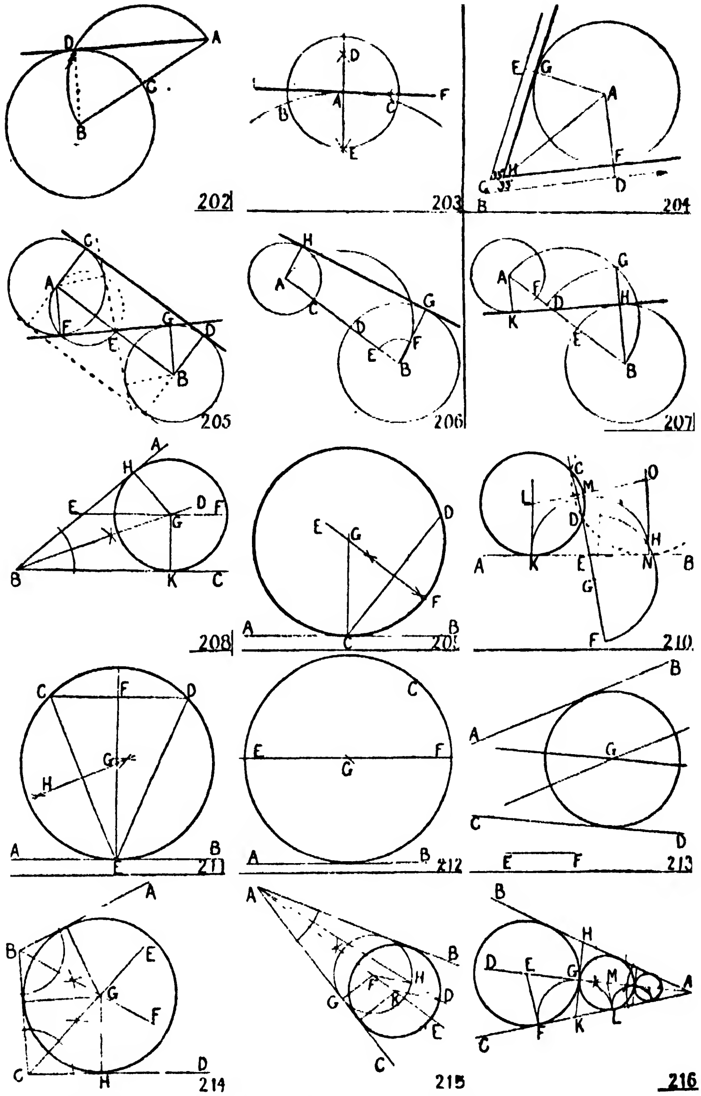
on the other side of the line joining the centres, and proceeding as above.

208. To Inscribe in a Given Angle, *ABC*, a Circle of Given Radius (say, ·4 in.). Bisect the angle *ABC* by the line *BD*, and draw *EF* parallel to *BC* and ·4 in. from it, intersecting *BD* in *G*. With *G* as centre and radius ·4 in., describe the circle touching the sides of the angle in *H* and *K*. The points of contact are found by drawing from *G*, *GK*, and *GH* perpendicular to *BC* and *BA* respectively.

209. To Describe a Circle Passing Through a Fixed Point *D*, and Touching a Given Straight Line *AB* in a Fixed Point *C*. Join *CD* and bisect it by the perpendicular *EF*. Through *C* draw *CG* perpendicular to *AB*, and cutting *EF* in *G*. With *G* as centre, and radius *GC*, describe the required circle.

210. To Describe a Circle Tangent to a Given Straight Line *AB* and Passing Through Two Fixed Points *C* and *D* without the Line. Join *CD*, and produce the line to cut *AB* in *E*, and make *EF* equal to *EC*. Bisect *DF* in *G*, and draw a semicircle on *DF* with radius *GF*. At *E* erect a perpendicular to *DF* cutting the semicircle in *H*. Mark off *EK* from *E* on *EA* equal to *EH*. At *K* erect a perpendicular *KL*, and bisect *CD* in *M* by the perpendicular *LM*, which also cuts *KL* in *L*. With *L* as centre and radius *LK* draw the required circle. When *AB* is not parallel to *CD*, *two circles* can be drawn as shown.

211. To Describe a Circle Tangent to a Given Straight Line *AB*, and Passing Through Two Fixed Points *C* and *D*, which are Equidistant from the Given Line. Join *CD* and bisect the line in *F* by *FE* cutting *AB* in *E*. Join *CE* or *DE*, and bisect it by *GH* cutting *EF* in *G*. With *G* as centre and radius *GC* describe the circle.



202–216. PRACTICAL GEOMETRY: CIRCLES AND TANGENTS

212. To Draw a Circle Passing Through a Given Point *C*, touching a Given Straight Line *AB*, and having a Given Radius (say, ¾ in.). Draw a line *EF* parallel to *AB* and ¾ in. from it. With centre *C* and radius of ¾ in. intersect *EF* in *G*. With centre *G* and radius *GC* describe the circle.

213. To Describe a Circle of a Given Radius *EF*, to Touch Two Converging Lines *AB* and *CD*. At a distance equal to *EF* draw parallels to *AB* and *CD* intersecting at *G*, the centre required.

214. To Describe a Circle Touching Three Given Straight Lines, *AB*, *BC*, and *CD*, which Make angles with Each Other. Bisect the angle *DCB* by the line *CE*, and the angle *CBA* by the line *BF* intersecting *CE* in *G*. From *G* draw perpendiculars to the three given lines, then either perpendicular is the radius of the required circle.

215. To Describe a Circle which shall Touch Two Given Converging Lines *AB* and *AC*, and Pass Through a fixed Point *D* Between Them. Bisect the angle *BAC* by the line *AE*. Join *D* with *A*. From any point *F* in *AE* draw *FG* perpendicular to *AC*, and describe a circle touching *AB* and *AC*, and cutting *AD* in *H*. Join *FH*, and through *D* draw *DK* parallel to *HF*, cutting *AE* in *K*, which is the centre of the required circle.

216. To Describe Two or More Circles Touching Each Other and Two Converging Lines *AB* and *AC*. Bisect the angle *BAC* by the line *AD*. From any point *E* in *AD* draw a perpendicular to *AB*. With *E* as centre and *EF* as radius describe the circle touching *AB* and *AC*. Draw *HK* tangential to the circle. Make *KL* equal to *KF*, and at *L* erect a perpendicular to *AC*, cutting *AD* in *M*, the centre of the next circle.

W. R. COPE

How Much Food a Man Should Take. The Risks of Underfeeding and Excess. The Best Foods. A Well-varied Diet Necessary.

THE MOST REASONABLE DIET

We have studied in the last chapter the chemical constituents of food, and have seen in what proportions they ought to be consumed. But we find in actual life vast differences in the amount and character of food taken by different people, and often it is very difficult to discover any corresponding differences in health. A man is sure to die if he attempts to live on sugar and sago and suet; he is sure to die if he allows himself food of only 600 calories fuel-value; but one knows that men may live on dates and milk, or on minced meat and hot water, or on crusts and butter, and on nothing but vegetables, and yet apparently flourish. We know that the Scotch used to live mainly on oatmeal, and the Irish mainly on potatoes; we know that various Oriental peoples live mainly on rice, and yet we find all these nations apparently quite healthy.

Man's Adaptability in Feeding. That is quite true; man is a most adaptable animal. But for some adaptations he has to pay a big price; and though Nature allows him a great deal of rope, yet if he take too much he is sure to hang himself. Further, there are some liberties that seem small that he is not permitted to take, and there are some rules that seem unreasonable that he is not allowed to break. He may live on butter and beans, and not seem much the worse for it, but, as we have said, if he attempt to live on suet and sugar it will soon be time for an obituary-notice. He may manage to get along without beef, but if he decline to eat fresh fruit and vegetables he will fall a victim to scurvy. He may reduce the fuel-value of his food to perhaps 1200 calories, but if he halve that quantity he must steadily waste away.

We do not deny that man may live on very different dietaries; we merely wish to find out so far as possible what variations are impossible, and what variations are pernicious, and what quantity and quality of food are best.

How Much Food a Man Should Take. Let us first consider in a general way the question of the *quantity* of food good for a man. The quantity of food which men consume varies with individuals, and varies with circumstances. One day a man is taking exercise on the hills, and eats tremendous meals; another day he is in a stuffy office, and eats very little. One day it is hot weather, and he takes a lamb cutlet and some lettuce; another day it is cold, and he tackles an Irish stew, and makes a big hole in a suet-pudding. One man is naturally a big eater, and has porridge, and fish, and bacon and eggs, and various other things for breakfast; another man has only an egg and a bit of toast for breakfast; and yet another man has no breakfast at all. It is natural and right that exercise and fresh air should increase a man's consumption of food; his tissues consume more food-energy to provide for more work and heat, and he has to consume more food to refund the expenditure. Likewise it is natural and right that a man living a sedentary life in a stuffy office should reduce the fuel-value of his food, since he is expending little muscular energy and has his bodily heat well conserved. It is quite right, too, that one man should naturally require food of 4000 calories value, and another man food of 1600 calories value.

Risks Incurred through Underfeeding. But there are limits that cannot be passed without detriment and danger. If a man whose digestive organs and tissue cells are capable of building up daily 3000 calories of energy, by choice or necessity reduces his diet till it is down to 2000 calories in fuel-value, he may seem quite healthy, but his health, judged as energy, is impaired. He is not making so much heat as he did, his organs and muscles are compelled by his parsimony to do less work. The fires of his life, from lack of fuel, burn low. For a time perhaps his energy may seem as great as ever, but, if so, he is living on his reserves, and is on the way to bankruptcy. If he reduce his supply of protein to below twenty grams a day, or the total caloric value of his food to below 1000, he will weaken and waste away. These facts with regard to extreme variations are certain. The only question is whether a man should eat only as much food as heat and energy demand, or whether it is better and safer to eat rather more. Chittenden's experiments and the teaching of Dr. Keith have led many to believe that mental and physical efficiency are increased by a reduction of protein and of the caloric value of food to a point where it almost exactly balances the body's expenditure in heat and work. Without making experiments in a calorimeter, it is difficult to know what a man's normal expenditure of heat and energy is; if one begin cutting down a man's diet, his heat and energy are apt to decrease *pari passu*, and we may diminish his health almost without knowing it. No doubt a reduction in food, especially in the case of those who greatly over-eat, leads to a feeling of buoyancy and freshness, but this feeling is not always to be trusted, for the nervous system is the last to suffer from starvation, and is often fed at the expense of the other tissues.

Wiser to Eat a Little Too Much than Not Enough. Professor Chittenden's experiments were not conclusive, and it is probable that one can enjoy quite as much health and vigour when one eats more than the body

requires, as when one gives the body its pound of flesh and no more. The craze for reducing food to a minimum and protein to a minimum is not to be encouraged, and if a man be doing a great deal of muscular work he will be wise to eat heartily of sugar and carbohydrates, and not stint himself of protein.

It is often pointed out that Orientals do heavy work on very light diet, but it must be remembered that we do not live in an Oriental climate, and that the greater part of the food we eat goes to maintain bodily heat. It must also be remembered that Orientals have, as a rule, much less bulky muscles than Europeans.

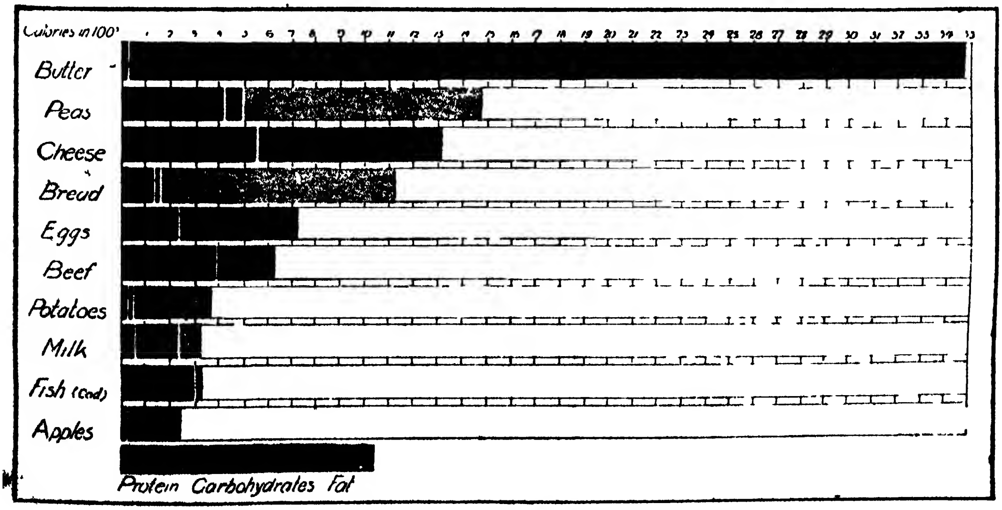
Wheat-Eaters Rule the World. For hundreds of years the Japanese have been small eaters, and their intake of protein has probably been quite down to the Chittenden 60 grams per day, but it is interesting to note that coincident with their recent rapid progress in civilisation has been an increase in the protein of their dietary. The Japanese soldier, indeed, is now given 150 grams of protein in his diet, which, considering his small stature, is about three times the Chittenden allowance. Protein seems to have a stimulating effect on the nervous system, and to conduce in some way to the production of heat and work. At the present moment it is the wheat-eaters and meat-eaters that rule the world; and though there may be some doubt which is cause and which effect, it is probable that a plentiful diet rich in protein has stimulated the mental and muscular activities of the ruling races.

Nor must it be forgotten that food has its effect on the character. A well-fed man is usually a genial man, and a man is usually most generous and kindly, most pleased with himself and the world, after a good meal. As the proverb has it, "A hungry man is an angry man," and those whose diet supplies them with sufficient calories merely for the bare necessities of the body will have little heat to spare to warm their hearts.

It is very possible, too, that underfeeding renders people more susceptible to various diseases, such as consumption, and that a moderate excess stimulates the production of the substances in the blood that resist the microbic diseases. A little fat both adds to beauty and serves as a reserve store of energy, and Nature meant that women especially should have a reserve store of energy with a view to the extra expenditure required by the physiological processes of child-bearing and child-nursing. All the muscles, be it noted, that have constant work to do have fat between their fibres. The diaphragm, for instance, has plenty of fat, and the heart muscle has generally a sufficient store of it to keep the heart going for five or six hours.

The best rule, then, would seem to be to take plenty of protein, and to eat rather too much than too little.

A little Too Much, but not Excess. But while we advise a margin we do not advise too large a margin. We find that the brickmakers in America, who do heavy work and earn big wages, consume food of the fuel value of no less than 8848 calories daily; while miners in America, doing quite as heavy work, consume only half as much. We find that American students eat twice as much as Japanese students. We find students living sedentary lives who eat enough food to fit them for navvy work. We find rich idlers, who toil not, neither do they spin, consuming meals of a food-value of perhaps 7000 calories. A certain margin may make for temperamental warmth, for initiative, for resistance to the diseases of low nutrition; a certain margin may lead to a sense of well-being, but when a man eats about 30 or 50 or 100 per cent. more food than he requires for heat and work purposes, he is not only guilty of greed and of self-indulgence and waste, but he is guilty of a crime against the laws of health. Such excess reduces both physical and mental energy, and leads to deposits of fat that still further diminish the working power of a man.



THE FUEL-VALUE IN CALORIES OF 1 LB. OF VARIOUS FOODS

We all know how a heavy meal produces circulatory and chemical changes that render a man, for the time being, sleepy, or at least disinclined for any mental or physical exertion; and just as some people are always more or less under the influence of liquor, so some people are always more or less under the influence of food. Fat accumulates under the skin, and, preventing quick radiation of heat, interferes with the combustion processes of life; it also accumulates round the heart, and hampers its movements.

The notion is pretty widespread that food makes strength, and that the more a man eats the stronger he will become; but a consumption of food *much* exceeding the needs of the body inevitably leads to a reduction in energy, and sometimes to disease and premature old age. Many people, without being gluttons, habitually over-eat without suspecting that they are doing so, and a little fasting or a curtailment in diet greatly increases their vigour and energy. No doubt this fact has sometimes led to extremes of teaching and practice.

Brain-Workers Must Not Over-Eat. Brain-workers require less fuel than manual labourers, both because nerve work means less breakdown of tissue than muscle work, and because usually this mode of life conserves their bodily heat; and it is brain-workers in particular who should be careful not to over-eat, since brain activity is specially diminished by too much food. True, we all know intellectual men who eat too much, and are too corpulent, and who yet get through an immense amount of work, but even they would probably be happier and healthier if they ate less.

To say how much food any particular individual should eat is almost impossible, for the amount of food depends largely on his capacity for building up food and using it as energy. One man may be able to utilise food of the fuel-value of 4000 calories; another man may not be able to utilise half that amount. Each man, starting with a few elementary facts—that he must have protein, and that over-eating and under-eating are both unhealthy—must find for himself the amount of food that keeps him in best health; that is, that gives him most energy. So much for quantity. Now let us look in a general way at *quality*.

Quality of Food. There are many kinds of flesh, many kinds of grain, many kinds of fruit. What articles of food are best to consume? That we cannot say. There seems, as we said before, to be little doubt that we should have proteins, and fats, and carbohydrates in our food, but which proteins, and which fats, and which carbohydrates, dietetic science does not pretend to be able to say. That there are subtle and possibly important differences in proteins, and fats, and carbohydrates seems certain, but which are best and which worst we do not know, though there are dietetic schools that claim to know a great deal. There is one dietetic school, for instance, that claims we should get all our protein from nuts and milk; and another school, equally energetic, that thinks we should get it all from vegetables.

We come of arboreal ancestors, it has been said, and therefore nuts are our natural food, but it might be retorted that if we come of arboreal ancestors we ought to live in trees.

Animal Protein Probably Best. On the whole, recent science has rather tended to controvert vegetarianism. Though it has been discovered that man can live on less protein than was formerly supposed, and that therefore the small proportion of protein in vegetables does not matter so much, it has been discovered, on the other hand, that the animal proteins are more completely and readily assimilated than the vegetable proteins; and it seems, too, that they are more provocative of energy. It has also been shown that the flavouring substances in meat, the so-called *extractives*, have a very potent influence in stimulating the digestive juices. And these discoveries, and the natural liking of men for meat, are a fairly good argument in favour of meat for dinner. Moreover, we are mammals, and the first proteins and carbohydrates we consume are animal, not vegetable, for we cannot consider milk a vegetable. And here, of course, most vegetarians are inconsistent, for though they disapprove of animal food they include milk and eggs in their dietaries.

The vegetarians declare that animal diet is immoral, because it causes suffering on the part of the lower animals, and they also assert that it tends to coarsen the temperament and tastes of those who indulge in it. But it may be doubted whether domestic animals used for food are not, as a class, more than repaid for any little suffering they undergo by the care and attention lavished on them by man; while the assertion about coarsening is a little difficult to prove. Most of the poets have been meat-eaters, and when Tennyson tried the "table of Pythagoras," he felt at first like "a thing enskied, a creature fairy-light," but after a few months he felt "chilled," and was glad to return to meat, and get back "the healthy heat his blood had lost."

Muscular Strength Without Meat. There can be no doubt that muscular strength can be perfectly well maintained without meat. The monkey, the gorilla, the buffalo, the hippopotamus, who, apart from milk, are strict vegetarians, cannot be said to be feeble creatures, or to be much weaker than lions and tigers, and the Scotsman who gets most of his protein from oatmeal, and the Irishman who gets most of his protein from potatoes, compare quite favourably in energy and physique with any John Bull who has been brought up on roast beef. Some Arabs, too, who feed chiefly on dates and milk, have fine physique and great endurance.

All this may be admitted, and yet there seems to remain a difference in favour of the meat-eater. The vegetarian animal has endurance, but the meat-eating animal has an activity and a quickness that the vegetarian animal as a rule lacks, and is capable of greater spurts of energy. Between the energy of a lion and the energy of a hippopotamus there is considerable difference, and probably between the energy of a vegetarian man and a flesh-eating man there is a difference of a similar kind.

Meat seems to have a stimulating effect on the cerebral centres, both emotional and intellectual, and to make for restlessness, initiative, and enterprise. When we are young we are told that we must not give meat to a cat, because it makes the cat "too quick with its claws." But the man "quick with his claws," on the alert, on the *qui vive*, is much more suited for the conditions of modern competitive life than a contemplative vegetarian with high views.

Vegetarian Food apt to Overload the Intestines. One great drawback to a vegetarian diet is the fact that vegetables contain an amount of innutritive substance, and that one requires to eat a large quantity of food in order to get sufficient nourishment. This means an unnecessary load, gives extra work to the intestines, and is apt, as in the case of the Irish "potato belly," to cause undue protuberance of the abdomen. On the other hand, in some cases of constipation the extra load in the bowels may stimulate them to action, and the beneficial results that sometimes follow on vegetarianism may be partly due to this cause. But we have not a digestive apparatus like cows and herbivorous animals to cope with big quantities of vegetable food; and in most cases, if only on account of the bulk of the food, vegetarianism is a tax, and an undue tax, on the digestive organs.

The danger of contracting animal diseases from animal food is very slight, and it is a danger that can be guarded against.

Dr. Haig's Dietetic Creed. Dr. Haig has a special dietetic creed of his own, and has made many converts, but his position does not seem to be scientifically tenable. He holds that work-power is derived exclusively from proteins, and "that the first requisite for strength and power of endurance is a satisfactory and sufficient supply of albumens, that the body depends for these chiefly on the food taken from day to day, but that there is also a small store of these substances in certain tissues that become available for use if prolonged exercise is called for in the absence of food, and further that beyond this point in continued starvation certain definite quantities of the tissues themselves are absorbed to produce the necessary albumen and urea."

Fatigue, according to Haig, is due to a defective circulation of protein owing to excess of uric acid in the blood, and all his efforts are directed to obtain a diet which will contain protein and yet produce no uric acid.

The uric-acid-free foods he recommends are milk and milk products, breadstuffs, cereal foods and glutens, garden vegetables, garden fruits, dried and foreign fruits. He specially recommends milk, cheese protene (milk protein), and gluten (flour protein) and nuts, and he rigorously excludes tea, coffee, cocoa, peas, beans, and lentils.

Here are two sample meals that he suggests:

I.

10 ounces of bread
2 ounces of oatmeal
2 pints of milk
2 ounces of cheese
1 ounce of nuts
18 ounces of fruits and vegetables.

2.

3 ounces of cheese
3 pints of milk
14 ounces of potatoes
16 ounces of fruit.

It is probable that Haig's diet would not improve the health of an ordinary, healthy man, but in some cases of disease it certainly proves to be distinctly beneficial.

Man Thrives Best on Mixed Diet. On the whole there seems every reason to believe that man thrives best on a mixed diet, and that a varied dietary is best for health. It is possible that in time to come dietetic students may have settled exactly what diet is best, and we mix so many ounces of such and such a protein with so many ounces of starch, and sugar, and fat. But meantime we have not solved all the problems of food, and we are constantly making surprising discoveries. Who would have imagined that lack of fresh fruit and vegetables would cause scurvy?

Some New Discoveries of Important Substances in Food. And quite recently, let us note, we have made other discoveries that have warned us not to be too exclusive in our dietaries, and not to imagine that nutrition is just a matter of so much protein, so much carbohydrate, and so much fat. We have found out that there is more in bread-and-milk than has been dreamt of in our philosophy. If we try to feed a young rat on pure protein, fat, and carbohydrate, with the right proportions of salts and water, it soon ceases to grow, but if we add to the dietary quite a small amount of milk the rat begins at once to thrive and grow. What exactly is the substance in the milk we do not know; it is very potent, but it is present in very small quantities. In wheat there is also a mysterious and potent substance which is abstracted from the most refined flour, thereby rendering it much less nutritious than whole-meal bread or the less refined flour in the bread known as "standard" bread. The substance in wheat is probably of the same nature as the substance in the protein of rice; and the same substance is probably present in meat and yeast, and egg yolk and other animal and vegetable foods. The substance has been called *vitamine*, but little is known about it. In porridge there is yet another mysterious substance that acts in some way upon the thyroid gland, a gland in the neck, which has much to do with development, and it might seem that to this substance in their native food the Scotch owe the robust physique for which they have been noted.

The moral of all this is that we had better eat meat and porridge, and fresh fruits and vegetables, and vary our diet as much as possible, for we never know what we may lose if we restrict our diet to narrow limits.

And here we may say that half the benefit derived from trips to the Continent and from residence at foreign spas is probably due to change of diet.

RONALD MACFIE

Green and Dried Fodder. Brewers' Grains. Feeding Cakes. Meals and Maize. Straw Food. The Acorn.

STOCK FOODS FOR CATTLE

Grass. Where grass is of good quality, it stands first as a food for farm stock, not only providing a ration at less cost, but involving the employment of less labour. It should, however, be young, and young grass is secured by the careful admixture of varieties which flower at different periods, and by the omission of those which are not appreciated by stock. Constant grazing ensures young and tender herbage, while judicious manuring, the land being dry, or, if necessary, drained, equally ensures high quality. Grasses of identical varieties are found on soils of different types, and yet cows will milk heavily and fatting cattle increase rapidly in weight in one case, while neither will respond in the other. This difficulty may be largely obviated by the supply of dung or artificial manures, or by folding sheep which are fed with cake. Similarly, where live-stock are turned out to graze upon poor pastures, good results will follow by the increase of their produce and the improvement of the herbage if they are simultaneously hand-fed with rich food.

The Feeding Value of Grass. Ten pounds of good dried grass is equivalent in feeding value to 60 lb. of mangels or cabbage, and to 100 lb. of white turnips; hence the importance of ensuring quality both in the grass and in the hay produced from it. Grass enables a farmer to feed his stock upon green or succulent food throughout the entire year, while it may be employed in conjunction with green forage, roots, and cabbage.

It has been demonstrated that the feeding quality of grass may be largely increased by the aid of artificial manures, and to such an extent that sheep fed upon a pasture thus improved will produce mutton equally as well as if, when grazing on unimproved grass, cake is added to their ration. The yield of grass on a pasture varies from 5 to 12 tons per acre; the smaller yield of poor grass on unimproved land suggests the importance of manure in order to secure a maximum yield combined with high quality. Such a yield may feed four times the number of stock.

Rye Grass. This is frequently grown as a special crop, and, where possible, is dressed with liquid manure after each cut, ensuring at least three crops in a season. In some cases, the soil being peculiarly adapted to its growth, the weights produced are enormous. Rye grass is one of the richest of green foods.

Clover. This food is richer in albuminoids than grass, and is better adapted for horses, swine, and sheep than for cattle. The practice of turning sheep into clover in this country in folds, or even in fields, is commonly adopted. When supplied to cattle, clover should be supplemented with a food rich in carbohydrates, such as maize meal, barley meal, or rice meal. When cut clover is supplied to horses, it should be allowed to wilt.

Trefoil and Lucerne. Trefoil is occasionally sown alone as sheep food, but a perennial plant of trefoil, whether in pasture or meadow, immensely improves its feeding value.

Lucerne is very largely grown in the United States (where it is known as "alfalfa"), Argentina, and the Continent of Europe, is adapted to the warmer districts and the deep, rich soils of this country. It is largely grown in the Eastern Counties, from Norfolk to Kent, and provides one of the richest of foods for stock of all kinds. Nothing is more useful for horses, whether green or dry; but, being rich in albuminoids, it may be advantageously supplemented with maize meal.

Well-balanced Rations. The following figures are suggested quantities of concentrated food which may be added with advantage to various green foods in order that the ration may be better balanced.

GREEN CROPS RICH IN ALBUMINOIDS

Lucerne	100 lb.	add maize	or rice meal	6 lb.
Sainfoin	125	,,	,,	4 ,,
Crimson clover	150	,,	,,	4 ,,
Vetches	125	,,	,,	6 ,,
Clover	140			4 ,,

GREEN FOODS NEEDING ADDITIONAL ALBUMINOIDS

Cabbage	150 lb.	add cotton	seed meal	2 lb.
Italian rye-grass	100	,,	,,	2 ,,
Rye	125	,,	,,	2 ,,
Maize forage ..	150	,,	,,	4 ,,

As lucerne may be cut three times between May and September, and still provide a fourth crop for grazing, it should be grown on every farm suitable to its requirements. Although cattle and horses may be tethered upon it, it is better to cut what is required a day before it is supplied to stock. By the aid of lucerne, horses, cattle, and pigs may be stall or sty fed. In four cuts from 15 to 25 tons per acre may be very readily secured in a season.

Sainfoin (Fr., *esparcette*; Ger., *Esparsette*). This crop is largely grown as sheep food, especially on the chalks and soils rich in lime. It makes an excellent change for sheep, and is cut twice yearly, yielding from 14 to 17 tons of green forage per acre. The hay is well adapted for horses, and is relished by stock of all kinds.

Vetches or Tares (Fr., *vesces*; Ger., *Futterwicken*). These are chiefly grown as horse and sheep food, sheep being folded upon the crops. Being rich in albuminoids, it is better adapted for both classes of stock when sown with a mixture of oats or rye, both of which enable it to stand up better. Winter vetches supply an early May green crop, while those which are spring sown are ready in autumn, so that the plant is available for a long period. Vetches should be consumed when young, inasmuch as they are more digestible, but never given to horses or cattle quite fresh. Where sheep are folded on the crop, they should be gradually accustomed to it. Vetches, when given in medium quantities with other foods, add to the milking powers of the cows, and are relished by swine. When grown for seed, the

straw, or haulm, being comparatively rich in albuminoids and carbohydrates, may be used for either cattle or horses with advantage. Vetch hay is seldom produced, but forms a substantial ration.

Maize (Fr., *maïs*). The experience of the writer, who has grown this crop during many seasons, is that it is one of the most valuable on the farm. On suitable land, well manured, and in a warm climate, from 20 to 35 tons per acre may be produced in a good season. The crop is cut and distributed among the cattle on the pastures during August and September. Maize is especially valuable in a season of drought, when it seems to thrive best. It may be cut up by the aid of a special chaff-cutter, and preserved in a silo for winter use. When green it is sweet, practically all edible if not too late cut, and, used with cotton cake or bean meal, is most valuable for cattle, sheep, and swine. A 20-ton crop yields three times as much non-nitrogenous food as a 10-ton crop of vetches, although the yield of nitrogenous matter is much smaller.

Rye (Fr., *seigle ;* Ger., *Roggen*). Green rye, apart from its value as one of the earliest green crops of the year, is almost as rich a food as average meadow grass, and therefore assists in bridging over the season between winter feeding and summer grazing. It should be cut while young, and employed as a soiling or forage crop in the manger or on the pasture.

Rape, Coleseed, or Colza. This crop is largely grown as a sheep food, sometimes combined with mustard. Under good cultivation it produces a large yield, and, being a rich food with a high nitrogenous ratio, is well adapted to its purpose. It should not be given to cows in large quantities, owing to its liability to impart a flavour to milk.

Cabbage (Fr., *chou ;* Ger., *Kohl*). Although apt to cause looseness among stock, cabbage is one of the best of the bulky foods. It is much relished, a good milk-producer, and, when grown in the form of thousand-headed kale, forms one of the best and most economical of sheep feeds. A ration for cattle is from 40 to 50 lb. daily, but cabbage should always be given in conjunction with dry foods, which include at least one variety of an astringent character, such as cotton cake or bean meal.

Gorse, Furze, or Whin. This well-known wild plant is really a rich food, but on account of its prickly character it must be bruised before it is supplied to stock. This is accomplished by the aid of a special machine known as a masticator. In districts where the supply is large it forms an excellent addition to a winter ration on farms where forage crops of the best class do not grow with freedom.

Sorghum (*saccharatum*) is a substantial plant which succeeds in this country during hot summers. It somewhat resembles maize in the stalk, but it is much finer and bears no cob. It is rich in carbohydrates, chiefly sugar, and, owing to its sweetness and succulent character, is much relished by cattle. Sorghum, which is one of the millets, however, is quite an uncertain crop.

Potatoes. This popular tuber, although yielding a much smaller weight to the acre than mangels, swedes, or turnips, is much richer in nutritious feeding matter than the mangel, containing 20 per cent. of starchy matter. When potatoes are largely grown, the unsaleable or small tubers form an excellent addition to the rations of a pig or of cattle, cooked or uncooked; 20 lb. a day are sufficient for a cow or bullock. We believe, however, that the most profitable method of utilising small tubers is to steam them for swine, and to use them in conjunction with skimmed milk and barley meal.

Carrots. On suitable soils large yields of this crop are produced, and form a most economical food. Carrots are highly relished by all classes of stock, and are especially valuable for cows and swine. For the former as much as 40 lb. a day may be given with advantage. They are rich in sugar, keep well, but should be fed in conjunction with the richer cakes and pulse meals. As many as 20 tons per acre may be produced on good, sandy loam.

Parsnips. These roots are similarly sweet and as nutritious as the carrot, both being superior to swedes and turnips. They form an advantageous addition to the ration of cows and pigs. They pay well, and will produce 12 tons per acre.

Mangels. This popular root is one of those farm crops which are practically indispensable where stock is kept. It varies in quality, some varieties, like the smaller as compared with the larger roots, containing much more feeding matter than the others. It is one of the greatest aids to the winter ration of cattle, for which it is pulped or sliced, and used in a mixture with other foods. It is valuable for swine and sheep, while the ploughman is glad to help himself to an occasional root for his horses. Feeding on mangels usually begins with January, while the bulbs, if carefully camped, will keep until the following July. It is superior in feeding matter to the swede, especially when not grown to too large a size, for the bigger the mangel the smaller the percentage of the feeding matter, which largely consists of sugar. For fatting stock the globes and intermediate, or tankards, are preferred, while the long reds are often selected for milk production.

Kohl-rabi (Fr., *chou-rave ;* Germ., *Kohl-rübe*). We have in this plant a combination of the root and the cabbage, the flavour more closely resembling that of the latter. Kohl-rabi does not produce such large weights per acre as either cabbage or turnips, but it is a splendid change for stock, and is especially valuable in a dry season. Including the tops, the weight grown reaches from 25 to 30 tons per acre, although the average crop is much smaller, chiefly owing to insufficient manuring and imperfect cultivation. Rabi is an excellent food for dairy cattle, and may be used with some freedom, inasmuch as it is not likely to flavour the milk.

Swedes (Fr., *rutabaga*) and **Turnips** (Fr., *navet ;* Ger., *Rübe*). These are two of the most extensively employed of succulent foods, although they are perhaps chiefly grown for sheep. Both are highly suitable for cattle, and both are usually pulped or sliced by machinery—a practice which is common for sheep which have lost their teeth, and for fatting and milking cattle. For cows the tops or crowns of the bulbs should be removed, as they impart a strong flavour to milk. Turnips, both white and yellow, are used early in the season, as they do not withstand frost, swedes being consumed next, as they are much hardier. Swedes are in most cases, especially in the southern half of England, eaten in the field by sheep as they stand, or after being pulled up with a pick.

White turnips are inferior to yellow turnips, as they contain slightly less sugar, while both white and yellow are inferior to swedes, which contain 2 per cent. more sugar. Swedes, however, in their

turn, are inferior to mangels. The swede differs from the turnip, as it possesses a neck, which is absent in the turnip. Both swedes and turnips are supplied to young stock which are being kept in store condition, although the quantity given to calves which have been weaned is at first but small. Fatting cattle receive large rations of both roots combined with chaff, meal, and cake.

Brewers' Grains. Although not a green food, grains may be included under the heading of succulent foods. They are at their best when sweet from the brewery, as they are more appetising and less likely to spoil the flavour of the milk, for the production of which they are chiefly employed. Unless the price is low and the distance to the brewery slight, it is questionable whether it is not more economical to use dry or desiccated grains which, by the addition of water, are practically brought to the condition of fresh, wet grains.

Fresh grains contain about 76 per cent. of water, so that it is necessary to haul three tons of water to every ton of dry feeding matter. The summer prices of brewers' grains should not be higher than 3d. per imperial bushel, although it is usual to measure by the brewer's bushel, which holds much less. As compared with bran costing £5 a ton, grains at 4½d. to 6d. per bushel are an expensive food. Where wet grains are purchased by the ton, the water contained is usually excessive; in any case, however, we believe that desiccated grains will be found most economical between autumn and spring.

FEEDING CAKES

Linseed Meal. Linseed is a food which is adapted for use only in small quantities, owing to its exceptionally high percentage of oil. The best method of preparing it for addition to a ration is that of steaming.. The quantity required is placed in water in any suitable vessel, and the steam conveyed to it direct from a boiler; failing this, it may be boiled in water, and when the oil has reached a form of emulsion it may be mixed with the food —chaff and meal—in the manger. It is well adapted for growing calves and young stock, and occasionally for cattle and horses, but only in very small quantities. Linseed meal is one of the most useful foods for young calves, being frequently employed as a milk substitute. It is cooked in water or skimmed milk.

Linseed Cake. The most popular of all purchased stock foods is linseed cake, which is a by-product of the linseed oil mill. Linseed or flax seed provides two important products—the fibre and the oil, which reaches some 35 per cent. of the weight of the seed, although many samples contain either more or less; thus, in a bushel of linseed, the oil averages about 18 lb. In the process of extraction some 8 to 12 per cent. of oil is left in the dry residue, which, pressed into cakes, is sold to farmers at prices varying from £7 to £9 per ton for the feeding of their stock. Under the new process of oil extraction by the aid of naphtha, the residue contains but a small percentage of oil—some 3½ per cent.—but slightly more albuminoids and carbohydrates. For fattening purposes and for calves, therefore, the old process food is undoubtedly better, but for general purposes, and especially for milking cows and store stock, the new process product, when the prices are relatively lower, will be found equally valuable. It is probable, however, that cake made in the old way provides rather more digestible nutritious matter. Linseed cake is essentially a food for calves or young cattle and fattening beasts, as well as for fattening sheep and lambs. In very small quantities it is useful for horses, as when given for putting on flesh and adding brilliance to their coats. For milking cows it is not equal to cotton cake.

Cotton-seed Cake. This product, also a residue or by-product of the oil mill, is made in two forms. We have first the raw cake containing the husk, which is tough and indigestible, and the decorticated cake, from which the husk has been removed. The husk contains some 1½ to 4½ per cent. of nitrogenous matter, but, remembering its high percentage of indigestible fibre, it is unfit for food, and even dangerous when given to young stock in substantial quantities. The prepared kernels of the seed, which contain some 27 per cent. of oil, are heavily pressed for its removal, some 40 to 50 gallons being obtained from a ton of seed.

The decorticated cake, which is bright yellow in colour and sweet and nutty in flavour, is much to be preferred, and although its cost is greater it is distinctly more economical than the common cake. All pure cotton-seed meals are similar to the best cake in these particulars. If tiny particles of the black husk are present in a meal, however, it is an indication that the husk has been finely ground and mixed with the pure meal. Cotton cake is neither used for horses nor swine, but it is a highly valuable food for fattening cattle and sheep owing to its richness in the three nutritious constituents of food, but in purchasing care should be taken to ensure, by guarantee, that the quality is good. Cotton cake may be mixed with linseed cake when necessary to moderate the laxative character of the latter. It is believed to influence the firmness of butter and the production of milk.

Other Feeding Cakes. Palm nut, rape, sesame, coconut, sunflower, and other cakes, which are chiefly used in Continental countries, are little known in Great Britain, though soya bean cake—very rich in albuminoids—finds increasing favour. Rape cake, a by-product in the extraction of oil from rape or colza seed, is not relished by stock, although it is rich in oil and other feeding materials, a remark which applies in still greater degree to palm-nut cake, which is of a more agreeable character; to coconut cake, which is exceptionally rich in oil and digestible carbohydrates; and to sunflower cake, which, while containing less oil, is quite as rich as the best cotton cake in albuminoids.

Beans and Bean Meal (Fr., *fève*; Ger., *Bohne*). Bean meal, owing to its purity, which the feeder can so easily ensure, is much used in Scotland for milking cattle. The bean is extremely rich in starchy matter and albuminoids, but poor in fat. It is seldom economical to employ the home-grown bean for stock, inasmuch as the farmer can realise higher prices in the market than would warrant him in so doing; his best plan is to purchase foreign beans and to grind or crush them for use. Bean meal costing up to £7 a ton may be employed with great advantage for cows and feeding stock up to 4 lb. a day, while for sheep crushed beans in small quantities form a valuable addition to a mixed ration. Crushed or cracked beans, as we have shown in our reference to the feeding of horses, form a great help to the animal where the work is severe, while an occasional handful to store pigs is most advantageous.

Peas and Pea Meal (Fr., *pois*; Ger., *Erbse*). The pea is a food which is supplied to cattle and sheep, chiefly indeed to milking cows, in

the form of meal in a mixed ration, and to the extent of 3 lb. or 4 lb. daily, and to swine with potatoes, and cracked or crushed in small quantities to sheep. Rich in albuminoids, peas form an invaluable addition to a ration, and, although also rich in starch, crops grown upon the English farm are more profitably sold and replaced by samples of foreign or colonial origin.

Lentils. Lentils are not often obtainable, but when the price compares with that of imported peas or beans they are a useful food in the form of meal, containing as they do similar proportions of albuminoids and carbohydrates and slightly more oil, but they should be clean and sweet. This is an important feature to remember in purchasing all varieties of imported pulse, and especially consignments from India and Egypt.

Barley and Barley Meal. Whole dry barley is supplied to poultry alone, but, having been cooked or soaked, it may be given to pigs or cattle, although the practice is quite uncommon. Crushed barley is occasionally supplied to horses, although as a food it is inferior for their work to the oat. Barley meal, however, is commonly supplied to cattle, forming part of a mixture of the fattening ration. It is still more frequently used for swine either mixed with water or skimmed milk. The offal barley grown on the farm, when crushed, forms a useful addition to the feeding ration of sheep.

Malt and Malt Sprouts or Combs. Malt is slightly superior to barley, as well as more palatable, owing to its sweetness, which is occasioned by the process of conversion of starch into sugar. It is, however, for the farmer to determine when to use malt instead of barley, the price for a given weight being, perhaps, the chief factor.

Malt sprouts is one of the most appetising of stock foods, and one which is especially rich in albuminoids, so that it may be employed with maize meal, roots, straw, and inferior hay, with great advantage.

Bran, Pollard, and Middlings. These by-products of the mill, which have been largely deprived of the starchy matter of the wheat grain, are among the most valuable of stock foods. Bran is not only nourishing, but, being laxative, possesses a valuable physiological influence. It is most palatable and sweet, and is consequently relished. It is rich in nutritious matter, of which it contains some 60 per cent., nearly 12 per cent. being albuminoids, so that it is naturally well balanced. It is useful as an addition to cotton cake and the pulse meals, and, when costing £5 a ton, is one of the cheapest foods on the market, but it should be pure and floury. Bran is specially advantageous as a ration in the form of a mash for cows at calving, or for ailing cattle and horses, but the feeder is cautioned against inferior samples, especially those produced in roller mills, some of which contain a high percentage of worthless husks or fibrous matter, which is employed as an adulterant. The wheat offals known as pollard, middlings, blues, and dan, to which many other local terms are applied, vary in character, appearance, and quality, in a high degree. These foods may contain 57 per cent. of nutritious matter, including 11 per cent. of albuminoids and 44 per cent. of carbohydrates, or they may reach 60 per cent. of the last named, as against 65 per cent. in the whole grain, and yet the best are approximately similar, or even superior, in feeding value. The finer offals are more generally used for swine, especially sows and their young, than for stock of any other kind.

Oats and Oat Meal. Reference to the feeding value of the oat in the ration of the hors. has already been made in the section upon horses No food, however, is of greater value as a constituent of the ration of calves and young cattle in general, of lambs and adult sheep and of cows, but in all cases the grain should be crushed. The oat, however, is too costly as a common stock food, but ground oats, in which the constituents of the whole grain are present, are commonly employed for poultry, and but for its somewhat costly character might be advantageously supplied to calves and lambs, mixed with chaff and other foods. Oat hay—that is, the dry oat plant which has been cut before ripening, and consequently containing all the nourishment of the grain and the straw—is excellent fodder for horses and cattle, but it should be cut into chaff.

Maize. Although maize varies in price, sometimes falling as low as 13s. a quarter of 480 lb., and at others reaching 26s., it is one of our most important feeding stuffs, owing to its weight per bushel and its richness in nutritious matter, of which it contains some 80 per cent. Maize, however, is poor in albuminoids, which it is therefore essential to add in some other form. Maize meal is chiefly used for cattle and swine, crushed or cracked maize for sheep and horses, and cooked maize for fattening pigs.

Rice Meal (Fr., *riz;* Ger., *Reis*). Rice meal is exceptionally rich in starch, of which it contains from 47 to 55 per cent., the albuminoids varying from 8½ to 11 per cent., and the oil from 8½ to 14 per cent., although it is doubtful whether the oil of rice can be regarded from a nutritious standpoint in the same light as the oil of cereals and cakes. In any case, rice is rich in feeding matter, and, at its average price, one of the cheapest foods on the market, when pure.

Straw. Wheat straw is commonly employed when cut into chaff for horses and cattle, but among the cereals it is inferior to oat straw, containing less of each of the three nutritious constituents of food. *Oat straw* is softer, probably more digestible and better adapted for stock, both in its long and short cut condition. There are, however, still doubts, as shown by each investigation which has been made, as to the proportion of straw which is digestible, and consequently valuable as a nutrient. *Rye straw* is too tough and too valuable for other purposes to be employed as an economical food, while *barley straw*—we refer to the winter variety—is not only inferior to other straws, but is an irritating material when employed for food or litter, and its use is often followed by the presence of insect parasites. The straw of summer barley is much superior to that of winter barley. The haulm, or straw, of *peas, beans*, and *vetches* is richer—bean straw in particular—in albuminoids than the straw of the cereals, while the other constituents are practically analogous. The straw, or haulm, of all the pulse crops—and the remark equally applies to the chaff, or husks and cavings—should be carefully preserved as animal fodder.

The Acorn. The *acorn*, so largely consumed by their own will in autumn by cattle, sheep, and pigs, and for which farmers are accustomed to pay from 6d. to 1s. a bushel to those who gather them, is a highly astringent food, containing only 38 to 40 per cent. of nutritious matter, chiefly carbohydrates, and it is questionable whether the risk involved in its employment is not greater than the benefit derived from its use. JAMES LONG

The Ultimate in Chemistry. Properties of Electrons. The Beginning of all Things. Science Tending Towards Philosophy.

"MATTER IS ELECTRICITY"

Having seen the fate of the electron, let us now see whether there is anything that can be added to our knowledge of its actual properties. It is known that the course of electrons produced under certain conditions may be influenced by the approach of a magnet. They are deflected, and this deflection can positively be seen by suitable illumination of the experiment. It is by means of this knowledge that we are able to ascertain certain properties of electrons. We are enabled to ascertain, for instance, their velocity. This varies with certain conditions. It was some years ago stated that these electrons move at a speed resembling that of light. In point of fact, they do not move so fast as light. Nevertheless, the speed of light is the only one with which that of electrons can be compared. There is no material body, whether an atom or a star, that has a speed in any way comparable to that of electrons. We may say that 10,000 to 100,000 miles per second about represents the limits, so far calculated, of their speed.

The Mass of Electrons. But a still more interesting question is that to which M. Poincaré alluded in the quotation on page 2555. What is the ratio of the electrical charge of the corpuscle to its mass, it having been noted already that this relation is constant for all corpuscles, from whatever "element" they may be obtained? It has been hinted that physicists seem steadily to be approaching the conclusion that the electrical charge of the corpuscle accounts for all its mass. A whole generation has passed since Sir Joseph Thomson first enunciated the remarkable idea that the inertia of matter is electrical. The considerations he advanced dealt with imaginary bodies, which were extremely small, and which moved at speeds comparable to that of light. Little was it then thought, except perhaps by the bold speculator himself, that the existence of bodies having those properties would one day be demonstrated! When electrons were discovered the question arose whether their actual properties showed correspondence with Thomson's mathematical reasoning, and especially with his doctrine that the mass, or rather the inertia, of a body increases with its velocity. The assertion of Sir Joseph was that an electrical charge upon a moving body possesses inertia, due to the electromagnetic disturbance which it creates in the ether through which it passes. As its speed increases, its inertia increases, and therefore its apparent mass. It has now been demonstrated, in the case of corpuscles, that their mass does increase with their velocity.

The Last Analysis of Matter. But this is the least important result of this inquiry, for Sir Joseph next proceeded to compare the experimental results with the results which should theoretically be obtained if we make the remarkable assumption that the electrical charge of the corpuscle can account for the whole of its mass, leaving not even what M. Poincaré calls "a little, a very little matter." Sir J. J. Thomson found that the two sets of results are in such close agreement that the minute differences between them may readily be disposed of as within the limits of experimental error. The conclusion was, then, that the whole mass of an electron is electrical—that is to say, is due to the inertia of its charge. Thus Professor Duncan emphatically says: "On this view, then, the to-and-fro motion of a pendulum and the electrical oscillations of the spark from a Leyden jar are simply two manifestations of an identical thing—the inertia of a charged body." Here, then, we have the root question of chemistry apparently answered in a phrase. "All mass is the mass of the ether; all momentum, whether electrical or mechanical, the momentum of the ether; and all kinetic energy, the kinetic energy of the ether."

In other words, in the last analysis, matter is electricity. At the same time, it should be added that we have not yet reached the whole truth in this respect. The lamentable loss of M. Poincaré has deprived us of the most profoundly equipped and critical mind, with the aid of which this question would have made far greater progress since this work first appeared.

The Distribution of Electrons within an Atom. At a very recent reception of the Physical Society of London to the Cavendish Laboratory, Sir Joseph Thomson made a few notes which may now be added to the foregoing. The physical study of the Röntgen rays, and the chemist's inquiry into the nature of the atom, are coming to be one and the same thing. Two notably distinct kinds of Röntgen rays are now recognised by physicists, and are called K and L radiations respectively, for convenience. The K radiations are "hard," or penetrating, and the L radiations "soft," or relatively non-penetrating. Sir Joseph Thomson believes the evidence to be clear that these very distinct types of Röntgen rays are dependent upon the existence of two rings of electrons within the atom.

The student will recall the interesting experiments of Mayer, and the ringed arrangement of electrons which was there suggested, and which corresponded to certain facts of the Periodic Law. Now Sir Joseph Thomson is in hopes that further inquiry will reveal perhaps another type of Röntgen radiation which will correspond to, and prove the existence of, a third ring of electrons within the atom. The idea is clear that the physical study of the types of Röntgen rays will reveal the internal structure of the atoms

which produce them. In Sir J. J. Thomson's own words, physicists may hope "to be able to see how many separate vibrating systems, how many rings of electrons there are inside the other; and, more than that, that they will be able, by the study of that radiation, to gauge the number of electrons in each ring, so that this study promises to give them the means of determining the distribution of electrons throughout the atom."

But there is another question which the reader will not permit us to neglect. When attempting to describe the corpuscular theory of matter, so far as it is at present formed, we declared that the electrons of the atom, being all negatively charged, tend to repel one another. They are bound together within the atomic whole by means of positive electricity. We have to conceive of the "foundation" of the atom as probably a sphere of positive electrification.

What is Electricity? We have not completely described the new theory of matter until we have answered, or, at any rate, raised, certain questions about this positive electricity. Where does it come from? What becomes of it when the atom disintegrates? And in what does it subsist? Even if there be no material basis for the electron, may there not be a material basis or foundation for this sphere of positive electrification?

We are unable to answer these questions. The nature of positive electricity is not yet comprehended. Perhaps it consists of particles, just as negative electricity does; that would seem probable. Yet, if it does, certain difficulties arise. For we seem to be able to explain the mass of an atom as the sum of the masses of its negative electrons. Hence it would seem that if there be particles of positive electricity they either have no mass at all or else their mass is so small as to be practically negligible. We do not seem to be able to answer these questions at present, because we cannot, so to speak, "get at" positive electricity. It is not shot forth from atoms as negative electricity is, and it seems to exist nowhere except as parts of atoms. The question of the nature of positive electricity is of supreme importance.

Did the World Ever "Begin"? In a cautionary lecture at the Royal Institution, Sir Joseph Thomson stated that our ignorance in this respect prevents us from determining the nature of the direction of natural changes. It seems that our ignorance of the properties of positive electricity leaves it uncertain whether "the universe began as a simple collection of homogeneous atoms, and is evolving into a complex thing which will ultimately become one huge atom, or whether it began as a complex huge atom and is now breaking down into simpler, smaller, and similar atoms." The question, in brief, is whether the process now seen is the upward or the downward phase of evolution. Surely this tremendous alternative will impress the reader with the importance of the great gap in our knowledge for which this apparently satisfactory phrase, "positive electricity," really stands.

One comment, however, falls to be made upon Sir Joseph Thomson's words, or, rather, his use of the word "began." We must ask him by what right he assumes any beginning. We must ask him whether he is quite sure that he can really form the conception that the universe *ever* "began." For convenience, no doubt, the physicist is justified in using such a terminology as this; but before we can accept it in the stupendousness of its full meaning we must invoke the judgment of the higher studies—psychology and philosophy itself—in order to decide whether the idea of a beginning in the old-fashioned sense of "creation" can really be credited: whether we must not rather conceive of the Eternal Power that is behind the universe not as having called it into being at a particular time—our very idea of time being merely derived from our observation of material changes in the universe—but as underlying, maintaining, and sustaining it from eternity to eternity.

The Supreme Importance of the New Chemistry. Here, at any rate, we must close our long discussion of the new chemistry, of the possibility of which only the few dreamed twenty years ago. It is a chemistry which is of no practical importance whatever at the moment to the practical man; it does not affect the price of sodium carbonate or coal gas, but *it deals with the fundamentals;* and we may be absolutely certain that our knowledge of fundamentals will ultimately prove to be of the utmost practical value. The hint has already been given that the new chemistry may lead us to the utilisation of energies beside which all the sources of energy that have hitherto been employed for human purposes are trivial.

But while the practical importance of the new chemistry is only on the horizon, its theoretical importance is present, and is almost overwhelming. We have failed in our task if that has not been already made evident. A few stray sentences here and there will, we hope, have suggested to the reader that the theoretical significance of these extraordinary studies is not only scientific; they deeply concern philosophy as well. There is no more important question in philosophy than the nature of matter, and now that question is being answered. Again, among the supreme questions of philosophy are those which relate to the past and the destiny of the universe. These questions will ultimately be solved with the aid of the knowledge of fundamentals which men have gained during the present century. Again, philosophy is concerned to know whether all the diversities of the world can be resolved into a single substance. That is one of her supreme questions.

The Ultimate of Matter. Here, again, the new chemistry is of an importance which we cannot overestimate. Not only has it made the notion of a few score indestructible elements of matter seem to belong to an almost prehistoric order of thought; not only has it found the common element of all these elements; it has done much more. It would have been a great achievement even to show

that, to quote Tennyson, there is "one element"—that in the last analysis all kinds of matter are one—but the new chemistry has done far more than this.

It has not merely shown us that atoms, though chemical ultimates, are not absolute ultimates, but it has shown that the apparent ultimate of which all atoms whatsoever are composed, the very ultimate of matter, is *in its turn* not an absolute ultimate. It is no more an absolute ultimate than the atom is. The new chemistry teaches us that the ultimate of matter is, in its turn, merely a particular variety or aspect of energy. If we attempted to state a category of the cosmos, writing down a list of the various things it consists of, we might graphically learn the significance of the new chemistry by comparing the length of such a list made ten years ago with the list that we may make today. The various chemical elements would have had a place in the old list. A little later their place would have been taken by the simple word "matter," it having by then been recognised that all matter is one. But now even that word would not appear, it having now come to be believed that matter is merely an electrical phenomenon. How much further the new chemistry leads us towards an objective, scientific, matter-of-fact proof of the philosophical belief that all things are one we cannot here pause to say.

Science and Philosophy. Surely, at any rate, we have said enough to convince the reader of the overwhelming importance of these scientific facts to the philosopher, who has no interest in the details of science for their own sake, but cares for them merely in so far as they may serve to aid him in his attempt to answer the questions of philosophy.

But, at any rate, we must here insist upon a profoundly important truth. It is that, as science advances, it constantly leads up to philosophy; again and again the historian of scientific thought finds himself led beyond his proper province into that of philosophy. Certain types of scientific mind resent any connection between the two studies. They regard any attempt to speculate or to recognise the ultimate importance of scientific facts as unscientific. On the other hand, certain types of philosophic mind, such, for instance, as the mind of Hegel, resent deeply the intrusion of science into philosophic questions.

Nature is Orderly and Intelligible. But we should be able to avoid both of these extremely common and extremely pernicious errors. It is perhaps the most distinguishing mark of the purely scientific thought of the nineteenth century to lead up to philosophical problems. If that generalisation, which has been clearly stated by Dr. Merz, the great student of nineteenth-century thought, be true of the nineteenth century, it is more and more abundantly true of the scientific thought of the twentieth century, the achievements of which are already equal to those of half a dozen centuries in time past.

Among the great truths which the new chemistry serves to strengthen is, first of all, the truth that Nature is orderly; and secondly, that she is intelligible. The idea of the universal range of law is more or less clearly before the minds of all of us. Yet, imperfect instruments as our minds are, we constantly find ourselves confronted by facts in Nature which seem to have no reason or sense in them. They seem quite arbitrary; they simply are so, and we have to accept them. Closer study invariably shows, and will continue more abundantly to show, nevertheless, that there are no arbitrary facts in the Cosmos. What could be less intelligible or rational, less reasonable, more arbitrary, than the existence of some eighty or ninety elements into which all matter could be resolved, but which were incapable of being any further resolved? But the new chemistry has shown us that the existence of these elements and their relation to one another, their history and destiny, are capable of an absolutely rational interpretation. Even in all the multitudinous facts of chemistry, which it might be thought that no one could predict, we find causation and continuity to be absolute and the arbitrary to be non-existent.

Dogmatism is Impossible. There are many types of mind. Some readers will be annoyed at the recent sections of this course, on the ground that they are not sufficiently prim, exact, and dogmatic. Other readers will be annoyed on the ground that we have made too great deductions from data that were not sufficiently secure. But, at any rate, we have done our best.

It must be most emphatically pointed out, however, that the reader must read these sections with great caution and reserve, not too hastily accepting any statements. Their value will lie, if they have any at all, far more in their power to stimulate and interest the reader's mind, so that he will closely follow for himself the great developments of the new chemistry, than in the actual setting forth of alleged facts. We cannot confidently say that any of the more precise details of the new chemistry are finally fixed. It is literally true to say that new developments arise every week, and that part of what was written in July comes to wear an antiquated look in August. Only those who live in the midst of it can realise the almost electronic speed with which our knowledge of these questions advances. One or two instances will be instructive, especially if they serve to show the reader that he must on no account consider his knowledge of the subject to be adequate when he has studied the preceding sections.

The Rapid Growth of Knowledge. For instance, what was said earlier in this course regarding the emanation of radium cannot now be regarded as an adequate statement of the facts. The reader must not imagine that the emanation consists entirely of immature atoms of helium. That seemed to be the probable interpretation until quite recently, but now it is necessary to recognise the further details which will be found stated above.

Again, only a few lines later, we referred to the evolution of radium from uranium. That evolution has been suspected for many years, uranium having, as the reader will remember, an atomic weight of 240, while that of radium is 225. But it was very difficult to prove, and for some time the absence of any positive evidence seemed to tell against this view. Now, however, it may be taken as the fact.

Radium and the Sun. Again, in discussing the presence of radium in the sun, we insisted on the profound alteration that its presence there—which is extremely probable—must cause in our estimate of the cosmical time-table. Fully recognising the importance of the principle which Lord Kelvin called the dissipation of energy [see PHYSICS], we ask ourselves as to various sources from which energy, available for human life, may still be expected. First in the history of our knowledge comes, of course, the gravitational shrinkage of the sun as considered by Helmholtz ; secondly comes the (extremely probable) presence of radium in the sun ; thirdly comes the discovery of untold stores of energy in every atom of the sun and every atom of the earth—energies so abundant that all the extra-atomic energies with which we are acquainted, put together, count for nothing beside them. Thus, even if there be no radium in the sun, there remains more than a possibility of one day tapping the intra-atomic energies and extending the life of man, who has behind him merely a brief history of a few million years, through æons and æons, inconceivably long and inconceivably numerous.

In concluding this part of our subject, something must be added to the paragraph in which an atom was compared to a solar system. There we spoke of the electrons as " constantly colliding with one another in their mad race within the atom," the result of these collisions being to expel some of them from the atomic system. Here we must remind the reader that the corpuscular theory of matter in its latest form enables us to advance very definitely beyond such a statement of the facts as we have quoted. In speaking of collisions we are using only a metaphor, and not a very good metaphor at that. We should remember how far apart the electrons are from each other, relatively to their size.

Expulsion of Electrons from Atoms. Furthermore, Sir Joseph Thomson has now provided us with a theory which makes the expulsion of the electrons from the unstable atom quite intelligible without our having to invoke any idea of collisions at all. We now believe that the electrons, or Beta rays, are expelled in virtue of the sudden transformation of a portion of the potential energy of the atom into kinetic energy, or energy of motion, which expresses itself by its power to carry some of the electrons out from the atom at the tremendous speeds we have described.

Recognising the law of the conservation of energy, we see, of course, that the new type of atom thus suddenly formed not only has fewer electrons, but also contains less energy. Lastly, we observe that the moment of expulsion, though it does not depend upon a collision, is yet determined by something equally sudden, notwithstanding the fact that it indicates merely a point in the steady and age-long radiation of energy from the atom. At last a critical point is reached, and the result is as sudden a cataclysm as if there had indeed been a collision.

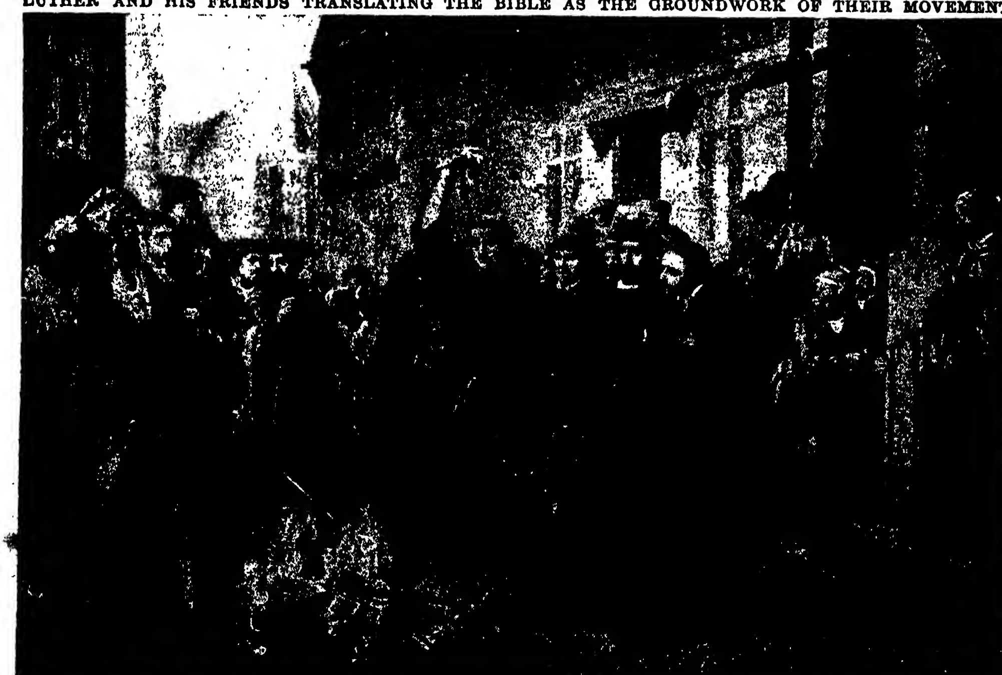
Nature Makes No "Leaps." Yet another point, which seems to demand more insistence than has yet been devoted to it, is this—that the processes of atomic evolution are not discontinuous and sudden. The old doctrine seems to be as true of the evolution of the atom as Darwin believed it to be true, or almost entirely true, of the evolution of living things : *Natura nihil facit per saltum*—Nature does nothing by leaps. The processes of atomic change are absolutely ceaseless and continuous. It is only the consequences of these changes that suddenly become conspicuous when the atom becomes unstable. But the new and stable atom which is then formed itself proceeds to undergo continuous change. The evolutionary doctrine is true here as everywhere else. " Nothing is constant but change." For practical purposes we may assume that atoms are stable, but the most stable of them are steadily journeying, even though the journey may take ages, towards instability. Spencer's law of universal rhythm is thus illustrated here also. Our attention is directed to certain striking moments in a continuous process, but we must not forget that it *is* continuous. Here, of course, is another illustration of that supreme generalisation which we express as the *continuity of Nature.*

"The Chemistry of the Carbon Compounds." And now we must pass, though very reluctantly, from our all too brief consideration of our subject, our knowledge of which will be recognised in time to come as constituting a great epoch in the history of the human mind ; a subject which no one would now hesitate to regard as epoch-making, if only it were a few centuries old. We must pass to a new division of the subject, though in doing so we must again remind ourselves that all our divisions are, at bottom, artificial, and that there are not two chemistries, but one chemistry. We are about to pass to what, not so long ago, was called organic chemistry. By this was meant the chemistry of those bodies which are characteristic of living things. It is quite distinct from what is now known as physiological chemistry—the study of the chemical processes which occur within the living body and play such an essential part in its life. But it has already been pointed out that the old division of chemistry into inorganic and organic is untenable; and in the next place we must devote ourselves to a brief study of the principles of what we prefer to call the *chemistry of the carbon compounds,* and of the reasons which render the use of that term desirable.

C. W. SALEEBY

SCENES FROM THE STRIFE FOR FREEDOM

LUTHER AND HIS FRIENDS TRANSLATING THE BIBLE AS THE GROUNDWORK OF THEIR MOVEMENT



MARTIN LUTHER'S REVOLT—THE BURNING OF THE POPE'S BULL

The Passing of Mediævalism. The Influence Under Which Old Things Passed Away and All Things Became New.

THE CHANGING CENTURIES

The division of history into periods, labelled ancient, mediæval, and modern, is of necessity arbitrary. There was a time, which we commonly call prehistoric, when the European peoples kept no written records of their civilisation. Then some of them, already in many respects highly organised, preserved their records, and ancient European history began. When did it end? We take the line of demarcation at the epoch or moment of time when the old civilised races ceased to dominate the known world, the world which preserved its records, and found themselves dominated in turn by new barbaric races—races, that is, which were on a lower intellectual level, and were politically in a less advanced state of organisation; a moment which we identify with the dissolution of the Roman Empire.

When Does Modern History Begin? Thenceforth European history is mainly that of the progress of these races from that barbaric condition to the highly elaborate organisation which they have attained at the present day. How, then, in the course of this continuous process—still proceeding—are we to draw a line anywhere saying that on one side of it is transition—mediævalism—on the other modernity? There is reason in the view which takes the close of the eighteenth century as the dividing line, on the double ground that the French Revolution politically rang the knell of absolutist and aristocratic systems of government, and that socially the industrial revolution—which, by the development of machinery, made manufacturing possible on an enormous scale—introduced the most essential features of modern life.

A Sound Popular Instinct. On the other hand, there is reason also in the view which finds the starting point of progress, the emergence from barbarism, in the intellectual and æsthetic revival which began in Italy before the thirteenth century was well ended. There is less reason in the purely picturesque popular distinction which realises the "Middle Ages" as the time when battles were fought by mail-clad knights, and modern times as the period in which gunpowder had made the coat of mail absurd. Nevertheless, this popular distinction does happen, in point of time, to coincide with a line of demarcation which seems on the whole to have a stronger claim to acceptance on general grounds than either the French Revolution or the beginning of the Renaissance.

The True Change to Modernity. Between 1440 and 1520 many events took place—beginning with the invention of the printing-press and ending with the Diet of Worms—any of which may from certain points of view be claimed as "epoch-making." There are so many fields in which at some moment during those years one era may be said to end and another to begin that collectively they may be regarded as the passing from mediævalism to modernity.

Four Epoch-Making Events. The first of these events is the invention of printing, of which the full effects did not immediately make themselves felt, but which meant that information and knowledge could soon be communicated *urbi et orbi*; no group of persons could claim to be the sole guardians of the arcana of accumulated wisdom. The general public slowly acquired the data for inquiry and criticism.

The second is the fall of Constantinople. Byzantium had carried on the Græco-Roman tradition. With its fall the south-east of Europe became, not a link between East and West, and between the old and the new, but definitely Oriental and Mohammedan; neo-Oriental, that is, with its past dating from the Hegira. The East had definitely become the aggressor against the West.

Third is the discovery of the New World by Christopher Columbus, and of the Cape route to India by Vasco da Gama, which made the ocean the great highway of the nations, and fleets the instrument of commercial success and the guarantee of expansion outside Europe.

Fourth is the challenge to the papacy flung down by Martin Luther—epoch-making, not as being the first of such challenges, but as being the first which resulted in a permanent reconstruction of the religious basis of European society, and in extensive political changes attendant thereon.

Growths in Art and Politics. As distinguished from these events, certain tendencies may be marked as reaching a climax or a decisive stage at this period. In Italy the æsthetic Renaissance reached its culminating point in the fields of painting and sculpture; the intellectual impulse, no longer concentrated in the south, was being communicated to the northern peoples.

The tendency to form large homogeneous states with a strong central government was overcoming the tendency to disintegration inherent to feudalism. In England, it is true, the principle had triumphed long before—it was only a reaction which was countered by the establishment of the Tudor monarchy. Now, however, France, under Louis XI. and Charles VIII., and Spain, under Ferdinand and Isabella, had been added to the lists of clearly defined states, and

the new conception expressed in the phrase "the balance of power" assumed a dominant value in international politics.

Gunpowder and the Tudors. Finally, a place, though not the first place, must be given to the revolution in the art of war effected by gunpowder, which had now become an assured if not an actually accomplished fact. In England, it may be added, the selected line of demarcation is peculiarly convenient, because it coincides with a landmark in the history of the country—the establishment of a particularly vigorous and notable dynasty. Modern England is introduced under the auspices of the House of Tudor, which supplied us with five monarchs, of whom three were unusually capable.

"Mediæval" history, then, ends and "modern" history begins—at least, so far as concerns Western Europe—with the opening years of the sixteenth century. And modern history itself finds a point of definite division in the epoch of the French Revolution. The years from the Reformation—Luther's defiance of the papacy—to the French Revolution form a clearly marked period in which the consequences of the events just enumerated ripen.

The Outburst of Liberated Science. The effects of the increased facilities for communicating knowledge, criticism, and ideas ramified into every department of human endeavour. After centuries of stagnation, even of retrogression, science—in the sense of knowledge of natural laws—progressed enormously. The 200 years which begin with Copernicus and end with Isaac Newton, whose middle period is associated with the names of Galileo, Kepler, and Francis Bacon, saw physics revolutionised, astrology displaced by astronomy, and the search for the Philosopher's Stone by a practical chemistry; while the eighteenth century witnessed the invention of machinery, which completely changed the conditions of labour, the first practical application of steam-power, and almost the first investigations of the nature of electricity.

The Rise of Great Literatures. With the exception of Italian literature, which, like Italian art, had already attained its zenith, all the great literatures of Europe came into being—though the Middle Ages had produced precursors, such as Chaucer in England—and achieved a splendour which remained unsurpassed, if not altogether unmatched, even in the period of the French Revolution or in the nineteenth century. The one exception was Germany, where, at the close of the period, Goethe had indeed risen above the horizon; but "Faust" was still unwritten, and Lessing's was almost the only name of consequence in pure literature. The sixteenth century produced the Portuguese Camoens, Ronsard and the Pléiade and Montaigne in France, Cervantes in Spain, Tasso in Italy, and in England the tremendous group of "Elizabethans," whose work extends roughly over the forty years from 1580 to 1620. To the next century belong Calderon in Spain, Milton and Dryden with Bunyan and Defoe in England, and in France the three great dramatists—Corneille, Molière, and Racine—as well as the school of critics, headed by Boileau, who dominated European literature for nearly a hundred years.

Literary Artifice Introduced by Criticism. Under this last influence intellectuality triumphed over passion, spontaneity was depressed by artificial rules; it is curious to remark that in England the term "artificial" was complimentary. Hence the victorious romantic reaction which followed this period makes the present-day critic inclined to deny that the pre-Revolution poets of the eighteenth century were poets at all. Through most of the eighteenth century classicalism held the field, tragedy ceased to be dramatic, satire and epigram flourished, but the lyric was at a discount; it was an age of essayists in prose or verse, though the tender emotions still found occasional expression.

The New Impetus to Philosophy. Neither in the field of prose literature nor in that of natural science would these developments have been possible—at least in their fulness—but for the invention of the printing-press. The same is true of developments in a third field which has affinities both with science and literature—the field which is vaguely and generally termed "philosophy." The "scholasticism" of the Middle Ages was not, indeed, so utterly sterile as is sometimes represented. In conjunction with the Reformation, which liberated thinkers from the necessity of compelling at least their publicly expressed conclusions to conform with the authorised dogmas of the Church, the printing-press helped both to record the data for formulating new ideas and to popularise new conclusions. In the sixteenth century the great theological contest absorbed attention, but the seventeenth produced the great names of Descartes, Spinoza, and Leibnitz; the next, Berkeley, Hume, and Kant.

The Philosophy of Government. Metaphysics, however, with mental and moral science, exercise a direct influence only on the few. Of more practically recognisable effect was the revived study of political theory, which may be said to have started with the publication of Machiavelli's "Prince" shortly after that statesman's death, in 1527. That work is a handbook of monarchism divorced from ethics, but it is an analysis of method rather than an examination of principles. The truth that the establishment of a strong central government was a manifest political necessity for every state which wished to hold its own accounts for the fact that the theorists, from Machiavelli through Jean Bodin to Hobbes, were always advocates of monarchism, though Hooper, in his "Ecclesiastical Polity," implies something like the ultimate sovereignty of the people. The philosophical thesis, however, was assuming by the middle of the seventeenth century the character of a political propaganda; constitutionalists, as well as absolutists, were in search of a theoretic warrant for their practical demands. The embodiment of the principles of the "glorious revolution" of 1688 in the constitutional gospel of John Locke, in spite of

prolixity and of a certain haziness, not only satisfied the Whig demands but influenced thinkers abroad. Montesquieu, analysing the functions of the state on the basis of what may be called comparative history and comparative law, pointed to British constitutionalism as the highest actual achievement in the art of government; the Encyclopædists undermined the logical defences of the "Ancien Régime"; Rousseau's "Contrat Social" captured the popular imagination, and became a mighty agent in producing the revolution itself. In practical manner the pen was seen to be no less mighty than the sword.

Pressure on Europe from the East. The fall of Constantinople was an event exceedingly striking to the imagination, but one of which the effect on the Western world may be exaggerated. The spirit which had flung the chivalry of the West against the East, the spirit of the Crusades, had all but spent itself 200 years before. The Austrian Hapsburgs, essentially a Western Power, were to find their Western policy for two and a half centuries continually hampered by the pressure of the Ottomans on the east. When the Ottoman power began to decline, the other Western states began also to interest themselves in an Eastern question, which did not, however, become acute, as far as they were concerned, till the nineteenth century. On the other hand, during the period of Turkish aggression they did not greatly embroil themselve in the struggle which the barrier states were obliged to maintain.

The Decline of Eastern Influence. Byzantium itself had long ceased to exercise any fascination or any marked influence over the Teutonic or Latin peoples; and the substitution of an aggressive Mohammedan power for a decaying Christian power in the Balkan peninsula was to all, except the barrier states, a matter of importance potential rather than actual. Moreover, the associated commercial problems, which otherwise might have forced themselves upon the West, were considerably modified by the steady and important development of the Atlantic as a commercial highway.

CROMWELL AND MILTON DISCUSSING THE PROTECTION OF THE VAUDOIS
From the painting by Ford Madox Brown

The Circulation of Eastern Manuscripts. Again, it is probable that too much has often been made of the effect of the fall of Constantinople on the intellectual movement of the West. The dispersion of Greek scholarship and Greek manuscripts which ensued did, no doubt, give an additional impulse to the study of the Greek tongue and the Greek authors of antiquity. But the classical revival had already begun in Italy; the demand for scholars and manuscripts had already been created, and the supply would have followed, though more gradually, even if the Turk had been driven over the Bosphorus.

The New Openings Westward. Of our third great event, or pair of events, however, it would be difficult to overestimate the significance and the importance of their development. In ancient times Greeks and Romans had indeed colonised Western Asia and the Mediterranean coast of North Africa. But the eastward movement had soon found its limit, had ceased, and had been revived only in very inefficient form by the Crusades, to perish again, submerged by the Turkish wave. It seemed that the peoples of Western Europe would be confined within the geographical limits of the continent. Now, however, the pathless ocean was converted into a highway to new regions, offering space to expand in, which might be called boundless, and infinite opportunities of commercial exploitation.

The Effects of Naval Supremacy. At first, indeed, the gold and silver of the West and the spices of the East seemed to be the chief prizes, and the monopoly thereof seemed to have fallen respectively to the Spaniards and the Portuguese. But then the monopoly was challenged by the two states which developed a maritime power greater than that of the monopolists. Dutch and English displaced the Portuguese in Indian waters, and the English found in North America a possession which they turned to better account than did the Spaniards theirs in the Southern continent. Then the French entered upon a rivalry with the English in India and in North America. The issue between the rival colonists in the West and the rival traders in the East involved them, and with them the parent states, in contests which meant in both regions the effacement of the one and the establishment of the other as monopolist. In both regions the British triumph was complete, owing primarily to the fact that the British concentrated their efforts on establishing naval supremacy, thus maintaining their own communications and cutting off those of their rivals; whereas the French, not realising this essential condition of a successful contest, allowed their energies to be simultaneously distracted by wars on the European continent. The victory of the British race took a new development when the race itself bifurcated into two nations as the result of a quarrel between the American colonists and the mother country, but that development was only in its initial stage at the close of our period.

The Revolt Against the Papacy. The fourth crucial event was Luther's challenge to the pretensions of the papacy. Those pretensions were both political and dogmatic. Politically they had attained their effective maximum in the thirteenth century, and had been weakened but not destroyed by the Babylonish captivity of Avignon and the Great Schism. Dogmatically they had been assailed by Wycliffites and Hussites, but the assault had apparently been repulsed. Now, however, the renewed attack by Luther developed into the revolt against Rome, both political and dogmatic, of approximately the northern half of Western Christendom. In the Southern states, Rome retained dogmatic domination, by accepting political alliances.

Conscience Without Toleration. Dogmatically, Protestantism rests on the individual's duty to obey his own conscience, and his right to follow his own reason, even when counter to the dictates of authority. The Protestants claimed the right and asserted the duty for themselves, but were not for a long time generally disposed to recognise either the duty or the right in the case of persons whose conscience and reason led to conclusions differing from their own. In other words, Protestantism did not realise that toleration was its logical corollary. It divided into camps, too antagonistic among themselves for the nations which adopted them to oppose a combined front to the attack of the papal powers.

Religion Tied to Party. In many countries, religious profession became so intimately connected with dynastic partisanship that "heresy," or "papistry," as the case might be, became treason in the eyes of rulers; and in England and Scotland a similar relation arose between Prelatists, or Episcopalians, on the one hand, and Puritans, or Covenanters, on the other, until mutual toleration was reluctantly accepted by both as the only security against papistry. Theological antagonisms, becoming exhausted among the educated classes, were replaced by a respectable indifferentism and apathy which extended into the moral and political spheres.

In the sixteenth and seventeenth centuries, religious convictions had been marked by intensity, even when moral standards were low. In the eighteenth, if moral standards were a shade more refined, religious convictions had given place to a tolerant scepticism which professed Deism and called it Christianity. Nevertheless, the instinctive demand for religious emotion found notable expression in England in the movement which bears the name of the Wesleys, which was but one form of the revolt of idealism against the self-satisfied materialism which devitalised Europe.

The Changing Spirit of the Centuries. In the sixteenth century, the Western world was stirred, as it were, by a fresh access of youth. It was an age of heroic adventure, of young enthusiasms, of dramatic incident—tragic and otherwise—of supremely picturesque personalities; the age which is summed up in Shakespeare. This flow of youth does not pervade the century which follows—an age in which the enthusiasms are sterner, the great personalities more grim. Its striking and characteristic figures are not Luther or Loyola, Henry, Elizabeth, Drake, or Marlowe, but Gustavus, Wallenstein, Cromwell, Richelieu, Milton. When we pass on to the eighteenth, barbaric energy and Puritan grimness give way to a pervading artificiality, polished scepticism, commercial materialism; there are very few figures that can be called noble. Among its most prominent figures, save perhaps Chatham and Washington, Frederic stands among the men who may fairly be called great; Walpole is more characteristic. The first century gave us spring; the second, summer and autumn; the third, winter. But another spring was to come, though with more in it of March than of May.

ARTHUR D. INNES

THE BRIDGE OF FAITH FROM OLD TO NEW

THE LANDING OF THE PILGRIM FATHERS: WHEN FAITH ASSERTED ITS CLAIM TO FREEDOM

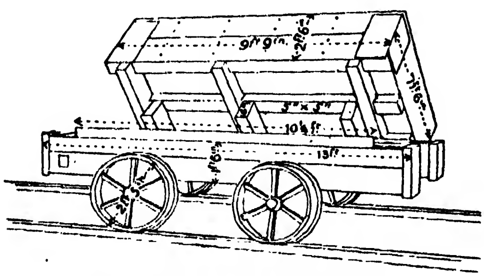
CROMWELL AT NASEBY: WHEN FAITH FINALLY SECURED THE FULL RIGHTS OF FREEDOM

The Contractor's Track. Locomotives and Waggons at Work. Finishing the Earthworks. Retaining Walls. Draining and Preserving the Embankment.

MAKING THE EMBANKMENT

THE earth is conveyed from the place where it is dug to the tip-head in waggons, of which there are two kinds- end-tip and side-tip waggons, the uses of which have already been described, and **15** and **16** give us a sufficient idea of the form and the arrangement of the parts of a side-tip waggon.

Temporary Way. It is usual to provide a temporary railroad for these waggons, and the rails to be used subsequently in the permanent way are sometimes laid down. The objection to this, however, is that the rough work of conveying earth upon ill-laid temporary roads is very apt to lead to the bending and distortion of the rails. The gauge of this temporary road is usually 4 ft. 8½ in., though this is rather on account of the convenience of using a standard gauge than for economy. Figs. **17** and **18** show contractor's temporary lines. The former includes a bridge made with a second arch so that the railway may be made four-track wide without unnecessary expense. If locomotives and trucks for a narrower gauge of either 3 ft. or a metre were ready to hand, the work could, in most cases, be done more economically by means of them. The rails for temporary purposes may weigh from 36 lb. to 56 lb. per yd., and are of the ordinary Vignoles section [**19**]. These rails are laid upon sleepers, the dimensions of which are 8 ft. or 9 ft. by 8 in. or 9 in. by 4 in. The dimensions naturally vary considerably, and old sleepers discarded from a permanent way of an open railway are frequently used. The sleepers are placed at distances apart which depend on the nature of the soil on which they are laid.

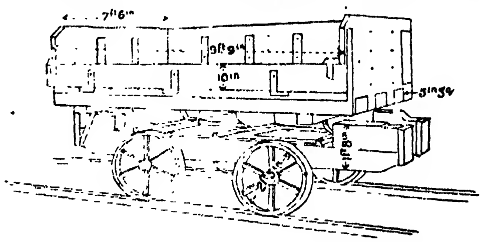


16. SIDE-TIP WAGGON TILTED

In slushy places they will be nearly touching each other, and on hard ground as much as 3½ ft. apart. If laid at a greater distance than 2 ft. 6 in. apart the sleepers, however, will suffer severely from the pressure of the rail upon them.

Rails. The rails possess considerable strength as girders, and do not bend very much in a vertical plane. The chief cause of the distortion of the rail is the accidental derailment of the earth-filled waggons, and such accidents take place very frequently on the roughly-laid temporary road.

The rails are fastened down to the sleepers by large nails about 3 in. long. These dogs, as they are called, have a chisel edge, and are so driven that the edge is placed across the grain of the wood. In driving the dog the fibre of the wood is thus displaced longitudinally instead of latitudinally, thus avoiding any tendency to



15. SIDE TIP WAGGON IN NORMAL POSITION

split the sleeper. The form of these nails is shown in **20**.

Two dogs are placed in each sleeper, but not opposite to one another, as this would increase the likelihood of the wood giving way. Attention should be paid to the position of the dogs. In **21**, A B represents the rail. If the dogs, instead of being driven as shown in black, were put as indicated by the open lines, the rail when bent laterally, so as to be convexed towards the bottom of the page, would be loosened from its fastenings. The dogs, therefore, are always knocked in as shown in the figure, those on the opposite rail being in the same position reversed, so that the sleeper is kept at right angles to the rails.

Sleepers. When the sleepers have been taken up and replaced several times—and such changes are necessarily very frequent on the temporary road—the dogs must always be driven in at a fresh place.

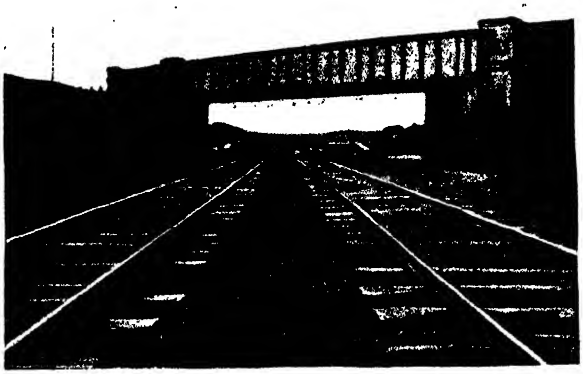
In time the wood of the sleepers becomes much weakened. Three dogs are often necessary, in which case it is usual to put two alternately on the inside and on the outside of the rail. When the timber of the sleepers no longer seems equal to holding them with sufficient firmness to secure the rail, planks may be laid down upon the sleepers on the outer side of the rail, and after being pressed against the rail may be nailed down on to the sleepers, forming a strong lateral support. This course is specially useful at crossings, where abrupt changes in the direction of the waggon cause considerable side pressure on the rails.

Laying the Rails. The length of the rails will vary from 15 ft. to 30 ft., and numbers of shorter lengths will be required for junctions, at the tip-head, and also where the steam navvy is at work. In laying them, the ground is first levelled; the sleepers are then laid down in place at a distance apart which depends upon the nature of the soil. The rails are then placed upon them, two or three men carrying each rail and laying it upon the sleepers. The ends of the rails are then fixed by knocking dogs into the sleepers nearest their extremity. The rails are afterwards similarly fixed to the intermediate sleepers. The rails are kept at the right distance apart while being laid with the help of an iron bar provided with projections at right angles to it. This is laid across the rails, care being taken that it is at right angles to both of them. The projections are notched at their extremity, to enable the distance between the rails to be diminished at the points and crossings, where too much clearance between the inside of the rails and the flanges of the wheels passing over them is dangerous. When the sleepers sink into the earth and the rails get out of level, the former may be *packed up*, as the operation is called, by shovelling earth beneath them.

17. CONTRACTOR'S TEMPORARY TRACK

The rails are joined together by means of fishplates, forming a joint, an illustration of which is given in 22.

Slewing. When for any reason the temporary line of rails should be moved on one side, the operation is performed by a gang of ten men provided with crowbars—*i.e.*, long straight bars of iron with a chisel end. First they move the earth from the end of the sleepers on the side towards which they are to be moved, so as to prevent obstruction. Then they get into position, five men at each rail, standing with their backs to the direction of movement with their crowbars between their legs. The crowbars are then put underneath the rails, between the sleepers, and, using them as a lever and the earth as a fulcrum, the men heave, raising the end of the bar in their hands. This raises the rails and the sleepers together, and the whole structure slips on the crowbars as they tend to the vertical position, so that the whole road is shifted laterally in the direction desired.



18. CONTRACTOR'S TEMPORARY LINES DURING THE CONSTRUCTION OF A RAILWAY

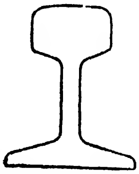
It will be found that for the temporary railroad broad sleepers are a mistake: they are apt to be placed further apart than narrower ones and to rock as a train goes over them. This loosens the dogs and works away the earth from beneath them.

When it is necessary to remove the temporary road, the bolts are taken out of the fish-plate and the dogs drawn from the sleepers. For the purpose of drawing the dogs, the men should be provided with special levers, having a curved bifurcated fork at the end, to engage in the ears of the dogs. By this means the dogs are very easily drawn out, and unless this instrument is at hand the men will endeavour to remove the dogs with a pickaxe, doing considerable damage to the sleeper.

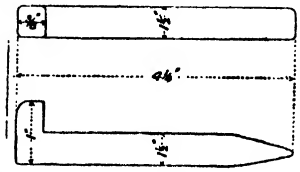
Points and Crossings. The points and crossings used on the temporary line are similar to those required for the permanent way, a full description of which is given under that head, but as a makeshift the arrangement illustrated in **23** is frequently used. A and B are pieces of rail about 9 ft. long, hinged at A[1] and B[1] by means of loose fish-plates. This enables them to be set in line with the rails passing to E or with the rails passing to F. Of these the right-hand rail of the one is at a distance from the left-hand rail of the other, and vice versâ, such that as on reaching AB the flanges of the wheel can just pass between. CD is a short piece of rail hinged in the same way, and when in position, as shown in the figure, it passes over the other rail which it crosses.

From what has already been said it will be

seen that the temporary road used for shifting the earth is neither very strong nor very carefully constructed; indeed, it would be un-economical to make it any better than is absolutely necessary for the work. It is consequently unsafe for an engine to be pushing a line of waggons, whether full or empty, at a high speed upon the temporary road.



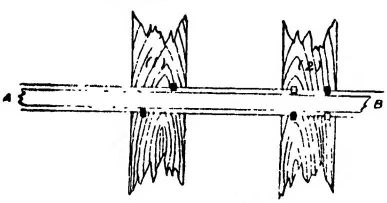
19. RAIL OF VIGNOLES SECTION



20. DOG SPIKES

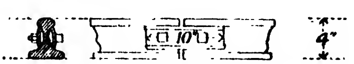
Position of Locomotive. As it is important for the locomotive drawing a train to be always in front of it, many devices are adopted to change the position of the engine from the rear to the front of the train. The most obvious method is that illustrated in **24**. The engine merely shunts the train into a siding communicating at both ends with the main line, and then detaching itself goes back and returns viâ the main line to re-attach itself at the other end of the train.

Reversing the Locomotive. The method described does not reverse the engine—which can be reversed, in the absence of a turntable, only by means of such an arrangement as is illustrated in **25**. The engine, it will be seen, is reversed by running over the triangle. Frequently the engines are not reversed from the beginning of a job to the end, though unless there is an arrangement to strew sand on the rails both in front and behind the wheels great inconvenience is caused.

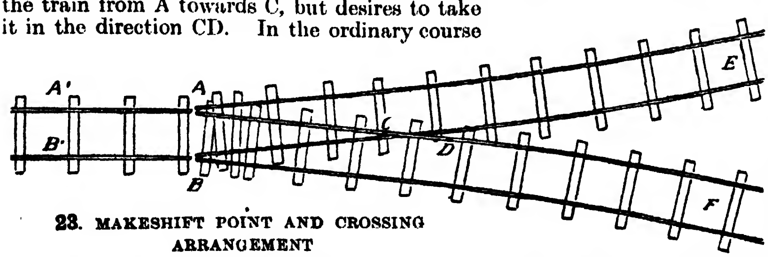


21. FIXING THE RAILS WITH DOG SPIKES

It may happen that there is no siding sufficiently long to accommodate the train and communicating at each end with the main line at the spot where it is necessary that the locomotive should be changed from end to end of a train. Under such circumstances, means such as that illustrated in **26** may be employed. The line CA leads, perhaps, from the place where the steam navvy is at work, the engine is drawing the train from A towards C, but desires to take it in the direction CD. In the ordinary course



22. FISH-PLATE JOINT



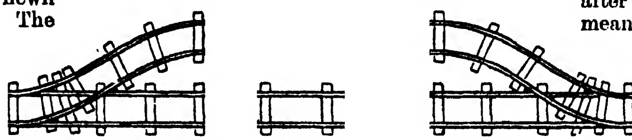
23. MAKESHIFT POINT AND CROSSING ARRANGEMENT

of things, being already in front of the train, it would be necessary to push it towards D, and to avert this the following manœuvres are performed. The engine, while coming along AC at the head of the train, is detached, and, increasing its speed, runs on to B. Here it reverses, and, putting on steam, runs along BD towards D, passing C before the remainder of the train, still moving by virtue of its initial velocity, arrives there; at D the engine stops while the waggons slowly pass over the junction C and come to a stop at B, when the engine can again be attached, and at the right end. This method, which is very convenient and obviates the necessity for a special siding, requires for consistent success that there should be a moderate slope from A to B to prevent the waggons from losing their speed too quickly. The waggons may otherwise come to a stop when only half over the junction of C, especially if a long train is being dealt with, thereby causing considerable delay and confusion.

Another common way to effect the same thing may be illustrated from the same figure. An engine pushing a train of waggons from B towards D desires to change its position to the front of the train. CD may be a siding on an upward slope leading to a quarry or spoil bank. The engine pushes the trucks up CA with some speed, but detaches itself before reaching C, and slows down. After the waggons have passed on to CA the points are altered, and the engine runs on to CD. The waggons, after coming to rest, run back of their own accord and come to a stop on CB, when the engine can reconnect itself at the right end. This process may be reversed and the engine be returned again to the former end of the train, as is often necessary when waggons have to be pushed up to a steam navvy which might be working in a blind or dead end at A. In these cases, as before, there is danger of the waggons stopping when but half over the junction. Manual labour must then be resorted to, and the trucks moved separately by levers between the spokes.

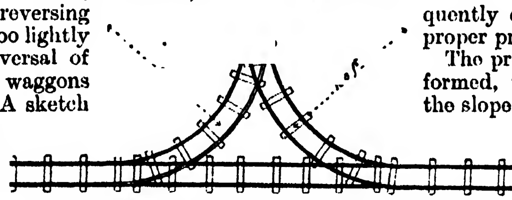
Derailment of Waggons. On the temporary line of way waggons containing earth are frequently derailed. The first thing to do in an accident of this kind is to disconnect the waggons from each other, then the engine, supposing it to be still on the line, as usually happens, proceeds to exert itself on the nearest truck off the line, provided the lower wheels and framework are entire. It is not difficult to get that wheel on to the line which

has come off on the inside of the rails, or it would not be difficult if it were not for the other wheel which has necessarily gone off on the outside of the rails so that the flange of the wheel is in the way in replacing it. In every case the method adopted is to extemporise an inclined plane on which the flanges of the wheel can roll, by means of loose sleepers and blocks of wood roughly hewn for the purpose. The engine is used to pull the nearest waggon up the incline till the bottom of the flanges of the wheels are on a level with the top of the rail, when they can be slipped on to them. Such an operation can often be performed without the necessity of emptying the waggons.



24. COMMON ARRANGEMENT OF LINES FOR SHUNTING

Reversing Waggons. Although it often happens for want of means of reversing that the locomotives may continue at work with their funnels in one direction for a considerable time, this can seldom apply to the waggons, otherwise end-tip waggons could be used only to tip at one end of the advancing railway, and side-tip waggons only on one side of the railway. A contrivance, therefore, is absolutely necessary for reversing waggons, though it be too lightly constructed for the reversal of engines, or even for the waggons themselves if loaded. A sketch of one of these is given in 27. The two circular pieces, B and C, slide upon one another while revolving on a bolt passing through centre of both. The contiguous surfaces are greased so as to diminish friction. The two rails are thinned out at their longer extremity so that when this arrangement is placed between the rail of the temporary way these extremities can be lowered upon the latter and the waggon run up upon them until its centre of gravity is approximately just over the central bolt, when two men can easily lift the extremities of the rail, and cause the circular piece B to revolve upon C. The thinned out extremities of the rail are then set down on the other side, and the waggon allowed to roll off on this opposite side.

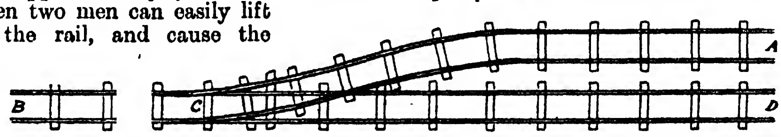


25. SHUNTING ARRANGEMENT FOR REVERSING ENGINE

Cuttings and Embankments. The lateral stability of a cutting or embankment is secured by sloping the earth away or supporting the side by means of retaining walls. The former, being the cheapest and most general, will be considered first. The slope adopted for cutting may usually be steeper than that for embankment, since the material of a tipped embankment is not found to hold so firmly together as the undisturbed earth at the side of a cutting. The most common slope for general purposes in cuttings is one to one, and for embankment one and a half to one.

Trimming. As already pointed out, the slopes of cuttings are usually trimmed to the ultimate profile with greatest economy shortly after excavation by means of a steam navvy has been completed. It is, however, frequently a waste of labour to do more than remove roughly the surplus material from the side of the cutting, since slips may subsequently occur which will require a more accurate trimming to be done over again. This is especially the case in a clay soil, as the behaviour of this material, when exposed to the weather, is often very treacherous. Embankments being liable to settlement or shrinkage, it is advisable to allow a considerable time after tipping before the trimming is completed, unless the degree of settlement or shrinkage can, by experience, be so well gauged as to enable the sides to be trimmed to an angle which will subsequently come to be that of the proper profile of the enkankment.

The process of trimming is performed, first of all, by dressing the slope to the correct angle and position at places from three to four chains apart. Where the line is on a curve, they must, of course, be made more frequent. The slope is obtained by means of a triangle, called a *batter* [28], provided with a plumb-bob in its shortest side. The proper position and angle of the slopes having been obtained at short distances apart, the earth is readily trimmed evenly between them. To avoid subsequent slipping of the material, it is frequently found necessary to drain the slope by means of ditches 2 ft. or 3 ft. wide, and from 9 in. to 18 in. deep, which may be filled with rubble stone, or with bricks. These usually extend about three-quarters of the way up the slope, throwing off two or more branches sloping upwards towards the top.

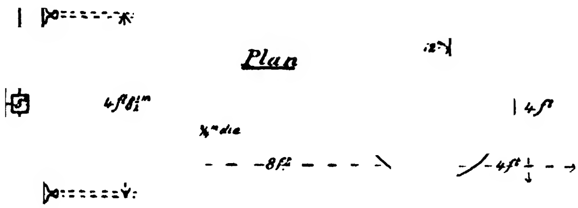


26. EMERGENCY SHUNTING ARRANGEMENT

Soiling. When the slopes have been trimmed, and any necessary drains completed, the surface is advantageously covered with a layer of vegetable soil, 6 in. or 8 in. deep. This soil is best obtained by removing the surface

of the ground to the same depth before excavating or tipping upon it. In most cases, the amount of soil thus obtained will be amply sufficient for covering the slopes to the same depth, and in a grass country sods may be cut from the original surface of the ground and stored, to cover the slopes subsequently.

If x [29] measure to the height of an embankment, and y its breadth at the top, also n the co-tangent of the angle slope, then, in the case where the quantity of surface soil is *no more than sufficient* to cover the slopes,



27. CONTRIVANCE FOR REVERSING WAGGONS

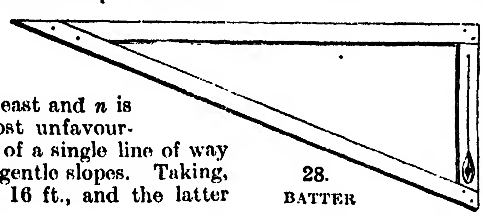
$$y + 2nx = 2x\sqrt{n^2+1}\,;\; y = 2x(\sqrt{n^2+1} - n)$$

$$x = \frac{y}{2(\sqrt{n^2+1} - n)}.$$

As it is obvious that, in the case of a very low embankment, the surface soil would more than suffice, it is evident that this value of x represents the greatest height to which an embankment could be carried if the soil required for the slopes were entirely provided from the original surface excavated to the *same* depth.

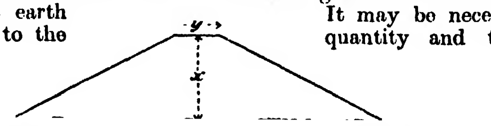
x is smallest when y is least and n is greatest, so that the most unfavourable case would be that of a single line of way on an embankment with gentle slopes. Taking, therefore, the former at 16 ft., and the latter at 2, we find that

$$x = \frac{8}{\sqrt{5} - 2} = 35 \text{ ft. nearly}$$



28. BATTER

The process of laying the soil upon the slopes is more difficult in cuttings than upon embankments, in spite of the fact that in the latter case the soil has to be got up the sides, and in the former it has only to be let down. The reason for this is that the slope on the embankment is always less than that of a cutting excavated from the same material, and when the earth is thrown with the spade on to the side of a cutting of the usual slope, about one to one, a large portion of it will begin immediately to roll down to the bottom. Thus, in soiling the slopes of cuttings it is usually necessary to place boards at intervals horizontally along the slope, and by means of stakes to erect them, and maintain them at right angles to the slope, while the soiling is being carried out.



29. DIAGRAM ILLUSTRATING THE SOILING OF AN EMBANKMENT

Sowing. When the soiling is complete, the sides of the slope are sown with grass. About three bushels of grass seed will suffice for an acre of the slope. A common mixture of seed consists of 1 lb. of clover to 2 lb. of rye grass.

The object of the grass is to protect the sides of the slope from the denudation of rain and water. The grass presents its leaves, and thus protects the soil beneath it, at the same time binding it together with its roots. The object of soiling is to assist the growth of the grass, and as the soil is in greater danger of being washed away before the grass has grown sufficiently to protect it, it is undesirable that the soiling of slopes should be proceeded with too long before the time of year suitable for growing the grass.

Retaining Walls. When it is decided, either on account of the nature of the ground or because of the value of the land, to support the sides of a cutting or embankment by means of walls, they may be built in the form shown in 30, according to the following rule.

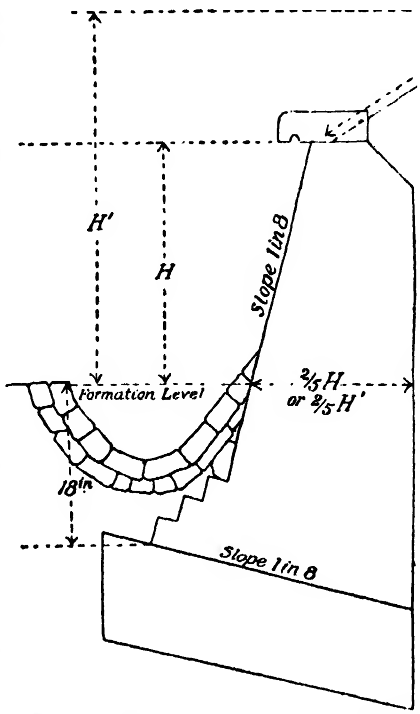
If the wall be not surcharged—that is to say, if the earth behind the wall be level with the top of it, the thickness of the wall at formation level should be made two-fifths of H, the height of the wall above this level. If, on the contrary, the wall be surcharged, and the earth rises above the top, the length H should be set off up the slope, as shown in the figure, and its vertical projection added to H, so as to make H′ as shown in the figure; two-fifths of this is then taken as the thickness of the wall at formation level. Formation level is, of course, the level of the ground upon which the permanent way is laid, and in the case of embankments, the ordinary level of the country applies instead of it. It will be seen by the figure that the retaining wall is built on a bed of concrete.

It may be necessary to vary the quantity and thickness of this according to the nature of the soil in which it is built. The cost of concrete is not usually less than that of brickwork, but the reason for using concrete for the foundations of retaining walls rather than extending the brickwork lower down is that the concrete can be put in without disturbing the earth at the side. This could not be done with brickwork, and as retaining walls usually fail by sliding forward bodily rather than by being overturned, it is desirable to have the earth opposing this movement in the firmest possible condition, and this

is provided by leaving it in its undisturbed natural state.

Preservation of Earthworks. In addition to soiling the slopes of cuttings and embankments, it is economical to round off the toes and shoulders of the work, to pave the ditches, and to provide tile drains for sub-surface drainage. The original cost of doing this is, however, considerable, and is often shirked, in spite of the fact that the work is fully justified by the subsequent saving effected in making good the effects of weather and floods, etc.

The greatest care should be taken that the top of an embankment does not become hollow like a trough. It frequently happens that the sleepers of the temporary road are packed up with earth at the ends, leaving a longitudinal depression in the centre. Before the permanent way is begun, or before the ballast is brought on to the line, this matter should be looked into, and the hollow, if present, should be filled with earth and rammed tight, otherwise it will be filled with ballast and perpetuated. After heavy falls of rain the water will then collect in pools beneath the sleepers, and ultimately work its way into the bank, softening it and causing spue-outs of earth below, and subsequently cracks and slips in the earthwork. This state of things once established is very difficult to remedy.



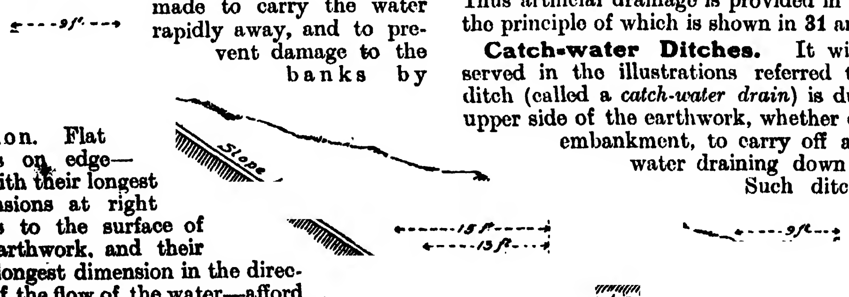
30. DIAGRAM ILLUSTRATING RETAINING WALL BUILDING

Erosion of Banks. In places where floods are liable to take place, provision must be made to carry the water rapidly away, and to prevent damage to the banks by erosion. Flat stones on edge—*i.e.*, with their longest dimensions at right angles to the surface of the earthwork, and their next longest dimension in the direction of the flow of the water—afford the best protection. When the base of a bank is liable to be eroded by the wash of waves—not sea waves, but the wave action of large sheets of water—a sufficient protection is often afforded by making the slope very flat.

Drainage. The secret of maintaining earthworks economically depends on the drainage. It must never be forgotten that wet earth and dry earth are two materials whose properties are different—often very different indeed. Some clays, for example, though hard enough and stiff enough to make excavation difficult, become by mere exposure to damp air a semi-fluid mass of treacly consistency. Such material is, of course, worse than useless for any structure whatever; but every gradation exists, and it is frequently necessary to make a cutting in earth too treacherous to be used in the formation of an embankment. Under these circumstances the excavated material must be tipped to "spoil" or waste. Often land must be purchased to receive it.

It must be remembered that the material used for embankment is subject to the endless pressure of its own weight, to disregard for the moment the pounding action of passing trains. Such pressures must be withstood while the earth is standing at an angle which is, as a rule, steeper than obtains in Nature. The side of a cutting made in a hillside is, for example, necessarily steeper than the part of the hill in which it is made, and it may be steeper than the slope at which the earth will permanently remain under natural conditions. The only thing to do then is to insure that this earth be dryer than natural conditions would allow. Thus artificial drainage is provided in a manner the principle of which is shown in 31 and 33.

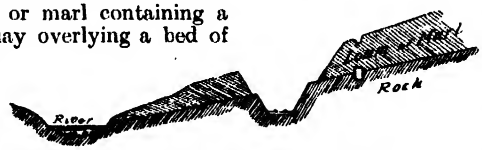
Catch-water Ditches. It will be observed in the illustrations referred to that a ditch (called a *catch-water drain*) is dug on the upper side of the earthwork, whether cutting or embankment, to carry off all surface water draining down the hill. Such ditches must have a sufficient slope longitudinally to prevent any water standing in them, and for the same reason should be periodically cleaned out. The



31. DRAINING A RAILWAY EMBANKMENT

ditches provided on the lower side of an earthwork are not so important, since these have to receive only the small amount of drainage issuing from the earthwork itself. It will be seen also that the ground on which the permanent way is laid, or the formation level, is also sloped at 1 in 30, and in **33** a *stone faced* drain is provided to take off the water. This provision is not always necessary, though in wet cuttings even more elaborate arrangements may be desirable.

Difficulties with Earthwork. Most of the troubles arising from suitable earthwork must be attributed to the agency of water. A typical instance is illustrated in **32**. Here we have a stratum of loam or marl containing a good deal of unctuous clay overlying a bed of hard rock, or some substance impermeable to water.



32. RAILWAY WHERE WATER CAUSES TROUBLE

The result of this will be that the upper stratum will retain a good deal of water, of which a considerable amount will find its way down to the surface of the hard rock, and, being thus arrested, will remain to lubricate further any movement or slipping in this plane.

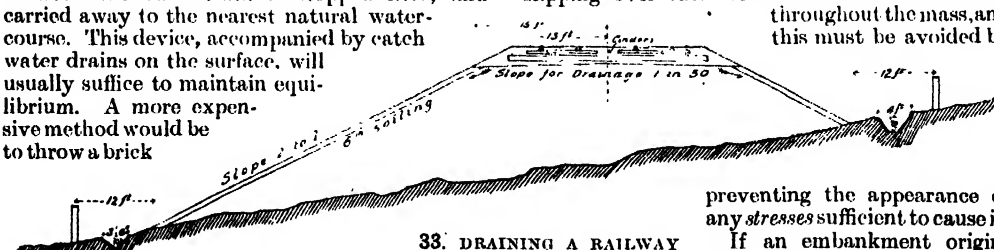
In its natural condition, the slope towards the river being very gradual, it may be that there is no likelihood of any movement taking place. But as soon as the cutting is made an entirely different state of things supervenes, and there is danger that the bed of marl or loam may slide into the cutting as fast as it is made and continue to do so until the whole side of the hill above it is brought once more to the natural slope at which it originally rested. Under these circumstances, the best plan is to drive a tunnel or heading some way back and higher up the hill, as shown in the figure, so that all water between the two strata is stopped here, and carried away to the nearest natural water-course. This device, accompanied by catch water drains on the surface, will usually suffice to maintain equilibrium. A more expensive method would be to throw a brick arch over the cutting and cover it in, thus re-establishing the former conditions as nearly as possible.

In the formation of embankments, all dangerous materials are, of course, avoided, and giving the railway the benefit of the doubt means discarding the material about which there is any question. But it frequently happens that the soil upon which an embankment is to be built is of a very difficult character to deal with.

Chatmoss. In the celebrated example of Chatmoss that was met with in building the first railway from Liverpool to Manchester, George Stephenson was confronted with something little better than a quagmire from 10 ft. to 35 ft. deep, and containing water to the extent of twice the bulk of solid material. He formed a secure foundation for heavy railway traffic in the following manner. Drains were cut about every five yards apart, and when the moss between them was quite dry, it was used for the embankment. On this were laid hurdles in single or double layers, and over them the ballast. By thorough draining in this way, cuttings as deep as 9 ft., and embankments as high as 12 ft., were formed in a substance in which an iron rod would sink with its own weight. In addition to good drainage, the introduction of the hurdles effected a wide and uniform distribution of the weight of the earthwork. This is an exceedingly important point in the formation of embankments upon treacherous ground. The effect of drainage is to strengthen the material by increasing its resistance to movement by slipping; but after slipping has once started, it is much more difficult to stop it than before it began.

Earth Slips. Slips take place in surfaces hidden within the material, and the particles of earth on these surfaces of slipping become turned as the slipping proceeds, thus loosening the material and affording readier access to the lubricating action of water, which immediately aggravates the slip.

An engineer must, therefore, proceed with his work so that no mass of earth has to sustain pressures sufficient to cause slipping to begin, in whatever condition it may be. A superficial slip—that is, a slip confined to the surface layers—is of small importance; a deep slip is naturally of greater consequence; but the most serious is a deformation of the earth caused by its particles slipping over each other in numerous surfaces throughout the mass, and this must be avoided by preventing the appearance of any *stresses* sufficient to cause it.



33. DRAINING A RAILWAY EMBANKMENT

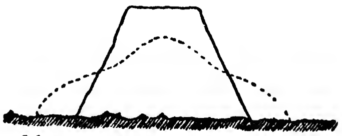
If an embankment originally tipped in the form shown by the full lines in **34** subsequently assumes the form indicated in exaggeration by the dotted lines, it is in a very bad state. An immense amount of earth must be tipped before the requisite height is attained, for it will continue to spread out as the weight superposed increases. Had the bank been originally formed at an easy enough slope, slipping would never have begun, and all serious trouble might have been avoided.

Similarly, when the earth upon which the embankment is tipped is at fault, the effect of imposing the extra weight of the bank on the surface of the soil is to cause profound deformation. Fig. **35** shows a common type.

The soil sinks beneath the bank, but rises beyond its limits, probably causing damage to

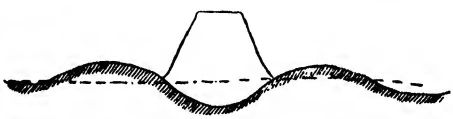
adjoining property, and in any case vastly increasing the amount of earth to be shifted. Had the bank been originally made in stages, as indicated in **36**, this difficulty would in all probability have been avoided.

Tipping on Soft Ground. The method in soft ground is to tip first the two small banks whose inner outlines are indicated by the dotted lines, thus distributing moderate pressures over a large surface of soil. Any tendency to movement of the soil would be in the direction of a rising between the two small banks. Of course, the appearance of such a thing would be a danger signal, showing the need for still wider distribution of weight; but the movement would not greatly weaken the soil in resisting the motion which the completion of the bank will most tend to bring about, being in a different direction. The slipping of this earth must be most carefully guarded against. It is a source of enormous expense.



34. SLIPPING OF EARTHWORK

Tipping Doubtful Material. In tipping doubtful material, any expedient calculated to remove water and keep it away should receive careful consideration. The work may even be stopped in wet weather. Snow should be removed before fresh material is tipped over it. In banks exceeding 25 ft. in height it is better to include no material regarding the subsequent behaviour of which there is any ground for apprehension. If, in spite of every precaution, a serious slip take place in an important earthwork, it will often be found cheapest in the long run to remove the whole of it and replace it with more stable material. The material removed may even be dried and burnt in heaps with coal or wood, and put back. This is a very fundamental cure, provided the whole of the bad earth be removed, since it converts it into one of the most satisfactory materials of which an earthwork can be made. But the expense is heavy, for, besides the cost of handling, the fuel required amounts to about a tenth of the weight of the mass if coal be used, or more if wood be used.



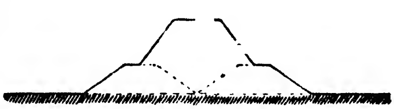
35. EMBANKMENT ON A FAULTY FOUNDATION

Foundations for Embankments. It is sometimes found necessary, in forming an embankment over soft ground, to make a foundation for this superincumbent mass by digging a trench of equal width, the sides of which are trimmed to the slope natural to the soft ground in which it is cut. This trench is then filled with stable material, and the embankment made upon the top of it in the ordinary way. The cost of this procedure is, of course, very heavy, and it is important that it should not be undertaken unnecessarily, or where simpler devices would serve. In cases where it is decided to adopt the method it is necessary to calculate the required depths of the trench with particular care, as it is this dimension which determines both the efficiency and the cost of the work. The expression

$$\frac{hw\left(\frac{1-\sin\theta}{1+\sin\theta}\right)^2}{w'-w\left(\frac{1-\sin\theta}{1+\sin\theta}\right)^2}$$

gives the depth required in which w' is the weight of the soft ground, w is weight of the filling, both in lb. per cubic ft.; θ is the angle of natural slope, or angle of repose, of the soft ground, and h the height of the proposed embankment.

Settlement of Embankment. The diminution in the bulk of artificially deposited earth begins at once and continues for years. Its amount varies very greatly according to the nature of the earth, its condition at the time it is put in place, and the manner in which this is done. The reduction in the height of an embankment which ultimately takes place from this cause is seldom less than 1 in. for every foot, and often amounts to twice as much. No rule can be given that is likely to be of practical use on the ground; but it is well to remember that earth will probably revert to the same density it possessed before it was dug in the first instance.



36. EMBANKMENT FOR A WEAK FOUNDATION

Allowance must be made for this in the construction of embankments, and these should in all instances be tipped so as to be of greater height at first than the plans and sections require by an amount which the experience of the engineer may decide to be necessary. In default of this, or if the experience of the engineer misguide him, the height will have to be made good by subsequent additions of earth. This would not matter so much if the subsequent additions of earth were confined to the top of the earthwork, but the effect of settlement is to reduce the slope of the sides at the same time, and the consequence is that the top of the embankment becomes in effect narrower than it was.

Additional earth must therefore be placed on the side as well as on the top of the earthwork, and this addition of fresh earth to a slope already partially consolidated is not conducive to solidity.

R. W. WESTERN

A valuable Series of Technical Dictionaries, explaining Special Terms and Phrases, appears at the end of the Self-Educator.

SCOTT'S TENDEREST PEASANT HEROINE

EFFIE DEANS—FROM THE PAINTING BY SIR JOHN EVERETT MILLAIS

A Short Study of Sir Walter Scott and his Works.
The Golden Key to the Kingdom of Romance.

THE WAVERLEY NOVELS

THERE is a tendency among some latter-day critics to belittle the great figures of our literary history. It is a simple way of attracting attention to oneself: to quibble about Shakespeare, to grow querulous with Scott, to sneer at Dickens. To write of our literary heroes with anything of the old enthusiasm, to avow oneself their thrall, is regarded, in certain quarters, as evidence of a commonplace mind. Well, these little, pettifogging critics have their day and cease to be, and their scribblings vanish as utterly as the grass that withereth. The heroes remain; nay, they grow greater, for their roots are deep-struck into the fruitful soil of their country's life. Let us be nowise afraid of displaying too much enthusiasm in their praise, though we may be denied the gift of eloquence. If we are told that nobody reads Scott nowadays, that he is out of date, let us forthwith see that we re-read him. Happier still will be our condition if we have any or all of his novels with which to make first acquaintance.

One of the noblest heritages of the Britisher is that glorious library of romance the "Waverley" novels. And soon or late most of us awaken to this knowledge; he who fails to apply it remains a poor man in midst of plenty. As Hazlitt said so happily, Scott's works, "taken together, are almost like a new edition of human nature." We are enthusiastic enough to believe that Scott is as much read to-day as ever; that he will be read as long as Edinburgh rock stands in the midst of an English-speaking town, even though the romantic castle around whose grey old walls he played in boyish games may have crumbled into dust. Scott is as firmly rooted in our national life as Edinburgh rock in Scotland's soil.

It is due to his novels that age cannot wither nor custom stale the infinite charm of SIR WALTER SCOTT (b. 1771; d. 1832). There are some writers who appeal to the instincts of men and women only at particular periods of their lives. The Wizard of the North claims the love and homage, if not of the seven ages, of five of them at the least. He is easily first of the great writers of English fiction. He is the father of the historical romance. If from the wide range of English literature two champions only had to be selected as representative, the selection would surely fall on William Shakespeare and Walter Scott. From every point of view we could spare these least of all of our great imaginative writers. If the student, the greater part of whose time is devoted to other than literary studies, should ask us to name the minimum of books essential to culture in its highest sense, we should say without hesitation: Read and re-read and make companions of the Bible, the works of Shakespeare, and the works of Walter Scott.

But we take it that the majority of the readers of this section of the SELF-EDUCATOR are students first of English literature, its byways as well as its highways, and that therefore they seek guidance to more than the best books themselves; that, in fact, as we have before suggested, they look for the man behind the book. In the case of Scott they have a noble quest. "This was a man!" And we must be brought face to face with him before we can fully appreciate the splendid work that is but part of him. Therefore, we would have the young student spend his days and nights after a while with Lockhart's "Life"—the second best biography in our language—and the equally moving pages of the now famous "Journal." Such time would be profitably spent.

If this advice be taken as a counsel of perfection, well, there is an admirable monograph by Mr. Andrew Lang, in the "Literary Lives" series. This brief biography, or rather appreciation, breathes that spirit of critical hero-worship which none but the best of men can inspire. Moreover, with the pen of the gifted writer displayed to its fullest advantage, Mr. Lang brings before us the man of whom he writes—a man whose life was a greater romance than, perhaps, any that has been written out of the fulness of his own or any other man's imagination.

Scott's Aims as a Novelist. The career of Sir Walter Scott illustrates, as Professor Raleigh points out, the renewal and decision of the old battle between verse and prose for the prerogative possession of romantic themes. Scott "took the bread out of the mouths of the novelists" by his metrical romances, "The Lay of the Last Minstrel" (1805), "Marmion" (1808), "The Lady of the Lake" (1810); then, turning to prose, he proved that the historical and romantic interests need not be imperilled by the admixture of qualities that are known only to prose. "In his works the novel proper and the romance, which had long been coquetting with each other, were at last wedded." Scott's genius was stirred by several causes—among them being the French Revolution, the Napoleonic wars, Percy's "Reliques of Ancient English Poetry," the songs of Burns, the ballads of Bürger, and the early poems of Goethe. Nor must the example of Fielding be discounted. But the Irish novels of Maria Edgeworth first inspired in him the thought which found such eloquent expression in that vast treasure-house of literature, the "Waverley" novels.

We commend to the student as steps preliminary to the reading of these novels (1) a consultation of the "General Preface," written by Scott in 1829, which will be found in the first volume of all good editions; and (2) the "Epistle," introductory to "The Fortunes of Nigel," written in 1822. Readers of the "Life" will appreciate the spur of necessity that drove Scott, who was never a laggard, to become a toiler by night and by day, in sickness and in health; no man of honour, genius, or spirit such as his was ever made the love of gain less the purpose of his labours. He explains, in the "Epistle" to which we refer, that he was quite aware of the aims of Fielding, Smollett, Le Sage, and others, as writers of novels, but he goes on to remark that it was enough for him could he "write with sense and spirit a few scenes, unlaboured and loosely put together, but which had sufficient interest in them to amuse in one corner the pain of body; in another to relieve anxiety of mind; in a third place to unwrinkle a brow bent with the furrows of daily toil; in another to fill the place of bad thoughts, or to suggest better; in yet another to induce the idler to study the history of his country; in all, save where the perusal interrupted the discharge of serious duties, to furnish harmless amusement."

History in Scott's Novels. Others before Scott, as both Professor Masson and Mr. Lang remind us, had attempted the historical novel, "but wholly without his knowledge of history and of the actual way of living and thinking in various periods of the past." He it was who first "made the dry bones of history live." The casual reader needs to be reminded of the stores of varied and accurate learning which were garnered in Scott's capacious mind. This man was a student from his youth upwards. It is important also to secure at the outset of our study of his historical works a knowledge of his methods of dealing with history. Scott's plan was never to make a famous character of history the central personage of his tale. He never coped with the records of actual events. But he achieved effects which were altogether denied to some of the most painstaking and letter-faithful among historians proper.

In all that Scott wrote, we breathe the free air of the mountain heights. He has made goodness interesting without beauty, without overmastering tragedy, without wallowing naked in the pathetic, without passion.

Scott's Manliness. His chivalry is a reproach to all who seek to achieve fame by meaner methods. "Scott had a sense of the reverence of human things: he did not lack the imagination necessary for the portrayal of the evil and terrible, but he did not seek success in that popular region. Scott was no prude, but he held the young in reverence, knowing that among them he must have many readers." For the reader with any true feeling there can be few moments in modern literature more memorable than that in which Diana Vernon (in "Rob Roy"), stooping down from her Highland pony, bids her lover farewell for ever. Yet Carlyle, all of whose references to Scott are not ungenerous, has placed on record the remark that Scott "fashions his characters from the skin inwards, never getting near the heart of them." Never was word more lightly spoken by man of intellectual weight. "Never," asks Mr. Lang, "never near the broken, stoical heart of Saunders Mucklebackit (in 'The Antiquary'); of the fallen Bradwardine (in 'Waverley'), happy in unsullied honour; never near the heart of the maddened Peter Peebles (in 'Redgauntlet'); never near the flawless Christian heart of Bessy Maclure (in 'Old Mortality'); or the heart of dauntless remorse of Nanty Ewart (in 'Redgauntlet'); or the heart of sacrificed love in Diana Vernon (Scott's early love); or the stout heart of Dalgetty (in the 'Legend of Montrose'), in the dungeon of Inveraray; or the secret soul of Mary Stuart (in 'The Abbot'), revealed when she is reminded of Sebastian's bridal masque, and the deed of Kirk o' Field?"

Scott's Leading Characters. "The glory of Scott's work," says Andrew Lang, "is, of course, not merely his wealth of incident, and his natural gift of story-telling, but his crowd of characters, from his princes, such as James VI., an immortal picture, Louis XI., Elizabeth, Mary, Charles II., in flight or in such prosperity as he loved, to his Highland chiefs, his ploughmen, his lairds, Bucklaw, and old Redgauntlet the persecutor; his copper captains in Alsatia, his bailies, his Covenanting preachers, his Claverhouse, his serving men, his Andrew Fairservice, his yeomen, his Dandie Dinmont, with the Dinmont family and terriers, his wild women—Meg Merrilies and Madge Wildfire"—Norna might be included; "his smugglers, his lawyers, from Pleydell to the elder Fairford, and even his bores, who, like Miss Austen's bores, are certainly too much with us—who can number the throng of such characters, all living and delightful? The author had, in imagination, lived closely and long with his people, whether of his own day or of the past, before he laid brush

to canvas to execute their portraits. It is as the creator of a vast throng of living people of every grade, and every variety of nature, humour, and temperament, that Scott, among British writers, is least remote from Shakespeare."

How to Read Scott's Novels. When the student, either from Lockhart's pages or those of Mr. Lang, has made himself conversant with the story of Scott's life, he will find in the novels much of the inner history of that life reflected. The reading of the novels in the order in which they were written is a revelation, and we strongly recommend that plan both to the literary aspirant and the general reader. The "Waverley" novels make excellent reading for the family circle; we mean for the reading aloud, with discussion afterwards, which is an aid not only to the better understanding of the author, but to many other things that are equally desirable. Such a method of reading will bring out into strong relief the wholesome philosophy of the author. Scott's novels, it must be remembered, do not depend for their popularity finally upon their plots. Taking time to arrange a story was a sore point with Scott. "I have," he has told us, "repeatedly laid down my future work to scale, divided it into volumes and chapters, and endeavoured to construct a story which I meant should evolve itself gradually and strikingly, maintain suspense and stimulate curiosity, and which, finally, should terminate in a striking catastrophe. But I think there is a demon who seats himself on the feather of my pen when I begin to write, and leads it astray from the purpose. Characters expand under my hand; incidents are multiplied; the story lingers while the materials increase: my regular mansion turns out a Gothic anomaly, and the work is closed long before I have attained the point I proposed." Scott himself is his own keenest critic. He tells us further: "When I light on such a character as Bailie Jarvie, or Dalgetty, my imagination brightens and my conception becomes clearer at every step which I take in his company, although it leads me many a weary mile away from the regular road, and forces me to leap hedge and ditch to get back into the route again."

Scott's Literary Style. It has to be remembered, also, that much which was new when Scott wrote has now become hackneyed, and as we do not base our claim for Scott on the excellence of his plots, so we do not fall back upon his style, of which the best that can be said is that it is a free and easy medium wherewith he brings more valuable things than style alone before us. R. L. Stevenson, who loved Scott and understood him as well as any critic that ever wrote of him, said many severe things about his literary style, and nowhere more aptly than in "A Gossip on Romance," which is printed in "Memoirs and Portraits," and should be read by the student. Scott was to Stevenson, as to every reasonable student of him, so gigantic that he could be made the subject of the severest criticism in details without in the least seeming to detract from the mighty mass of his admitted and unassailable merits.


THE HOME OF SIR WALTER SCOTT—ABBOTSFORD, ON THE BANKS OF THE TWEED

Chronology of the "Waverley" Novels. By taking up the novels in the order in which they were published rather than as fancy or other reasons may dictate, the student will be able to discern the workings of the author's mind when dealing successively with special phases of character and particular situations in human life. As to the introductions and notes, these are not essential to the story in hand, and may be reserved for consideration till each story has been read. With the remark that the authorship of the "Waverley" novels was for long a secret, in which rich and poor, from the throne downwards, interested themselves, it may be useful if we give a list of these works, with the dates of their publication, and an indication of the period with which they deal.

DATE	TITLE	PERIOD
1814	"Waverley; or 'Tis Sixty Years Since"	1745
1815	"Guy Mannering"	1760
1816	"The Antiquary"	1798
1816	"Old Mortality"	1679
1816	"The Black Dwarf" *	1708
1817	"Rob Roy"	1715
1818	"The Heart of Midlothian" * ..	1736
1819	"A Legend of Montrose" ..	1644
1819	"The Bride of Lammermoor" *	1700
1819	"Ivanhoe"	1194
1820	"The Monastery"	1559
1820	"The Abbot"	1570
1821	"Kenilworth"	1575
1821	"The Pirate"	1700
1822	"The Fortunes of Nigel" ..	1620
1823	"Quentin Durward"	1470
1823	"Peveril of the Peak"	1660
1823	"St. Ronan's Well"	1804
1824	"Redgauntlet"	1770
1825	"The Betrothed"	1187
1825	"The Talisman"	1193
1826	"Woodstock"	1651
1827	"The Surgeon's Daughter" ..	1765
1827	"The Two Drovers" †	1765
1827	"The Highland Widow" † ..	1755
1828	"My Aunt Margaret's Mirror" † ..	1700
1828	"The Tapestried Chamber" † ..	1780
1828	"The Laird's Jock" †	1600
1828	"The Fair Maid of Perth" ..	1402
1829	"Anne of Geierstein"	1474
1827–1830	"Tales of a Grandfather" ..	1707–1788
1831	"Count Robert of Paris" *	1090
1831	"Castle Dangerous"	1307

*"Tales of My Landlord."
†"Chronicles of the Canongate."

The Origin of "Waverley." A glance at the foregoing list will serve to show that with few exceptions Scott, with all his love of the Gothic, preferred to deal in his novels with periods not far remote from his own time; but he did for Scottish romance what Cervantes did for Spanish chivalry. Fourteen years before the appearance of "Waverley," Scott attempted the vein associated with the romantic tales of Mrs. Radcliffe and Horace Walpole. The first seven chapters of "Waverley" were written in 1805, and then, on the advice of a friend, put away, forgotten, and only recalled by the success of Miss Edgeworth and the task of completing "Queenhoo Hall," an unfinished romance by James Strutt. The lost MS. was discovered when Scott was in quest of fishing-tackle, and the story was finished in four weeks. These facts are of particular interest as showing that Scott did not take to the writing of prose fiction because Byron had beaten him in poetry. Thenceforward, for sixteen years, says Professor Herford, in his "Age of Wordsworth," "the wonderful series of the 'Scotch novels,' as they were called, issued from the Ballantynes' press without a pause; and for the last ten, at least, their appearance was watched for as eagerly in Paris and Weimar as in London. The poems had thrown the British world into a passing excitement; the novels enlarged the intellectual horizon of all Europe, created in half a dozen nations the novel of national life, and opened a new epoch in the study of history."

Two facts stand out clearly on a careful review of these novels: one is that the characters are types; the second is the wonderful fidelity of the descriptions of natural scenery. If the novels be classified it will be found that two-thirds of them are historical; and it is worth noting, as examples of the way in which Scott's pen "ran away with him," how "The Heart of Midlothian" grew into one of the most humanly interesting of his books from what at first was a desire to write a novel around the Porteous Riots, and how, in "A Legend of Montrose," history is again secondary to the creation of the immortal Dugald Dalgetty.

Scott as a National Asset. All literature is a national asset, and it is difficult to exaggerate what the British people in general owe to the author of the "Waverley" novels.

"Scott," as Professor Masson has said, "is greatest in his Scotticism. It is as a painter of Scottish life, an interpreter of Scottish beliefs and Scottish feelings, a narrator of Scottish history, that he attains to the height of his genius. He has Scotticised European literature. He has interested the world in the little land. It had been heard of before; it had given the world some reason to be interested in it before; with, at no time, more than a million and a half souls in it, it had spoken and acted with some emphasis in relation to the bigger nations around it. But, since Scott, the Thistle, till then a roadside weed, has had a great promotion in universal botany, and blooms, less prickly than of yore, but the identical Thistle still, in all the gardens of the world. All around the globe the little land is famous; tourists flock to it to admire its scenery, while they shoot its game; and, afar off, when the kilted regiments do British work, and the pibroch shrills them to the work they do, ask whence they come, the answer is 'From the land of Scott.'" It would be no extravagance if one were asked, "What is English romance?" to answer "Walter Scott." Yes; and French romance also, for his influence in France was profound. He is ours to read with delight, to learn from, to love, to use as the golden key admitting to one of the fairest kingdoms of earth—if it be not the veritable faëry land—the Kingdom of Romance.

J. A. HAMMERTON

Factories and Mines. Prisons. High Court. Museums. Patent Office. Insurance Commission and Labour Exchanges.

SPECIAL HOME APPOINTMENTS

This chapter is devoted to a consideration of certain special appointments in Government departments other than those that have been already described.

Home Office Posts. Foremost among such offices, in respect alike of the variety and the responsibility of its work, is the department controlled by the Secretary of State for Home Affairs. The main functions of that official himself are defined as "the maintenance of the King's peace, the enforcement of rules made for the internal well-being of the community, and the exercise of the prerogative of mercy." These duties include general powers of control over all police bodies and courts of summary jurisdiction, the support of a special civil force in London—the Metropolitan Police—the State inspection of factories and mines throughout the kingdom, and the maintenance of our local and convict prisons. For their performance the Secretary of State is provided with an enormous staff—clerical, technical, and executive.

The Metropolitan Police force, although in strictness a Government body, is paid chiefly from local rates. It was therefore included in the municipal section of this course, and is fully described on page 1251. Another special branch of the Home Office—the metropolitan police-court service—may be dismissed in a few words, as the Home Secretary now reserves its clerical appointments (£120 to £650 a year) for members of the Second Division who are recommended by their chiefs. Ushers and messengers in this service owe their posts to private influence brought to bear upon the Secretary of State.

Factory Inspectors. To protect the workers in factories and workshops from excessive hours and unhealthy conditions of labour, a small body of experts, under the Home Office, is constantly engaged in visiting these centres of industry, and in warning or prosecuting the offending firms. The staff numbers about 210 in all, including assistants and lady inspectors. Every candidate for this service must first be nominated by the Home Secretary, and is then required to pass an examination (which is most often mildly competitive) in certain specified subjects. Forms of application for nomination can be obtained from the private secretary to the Secretary of State, Home Office, S.W.

It is of importance to note that applicants are selected according to their practical qualifications rather than the private influence they may be able to secure. Proofs of an intimate knowledge of factory or workshop administration, for instance, coupled with high testimonials of ability and character, are the likeliest passports to a nomination to this department.

For male inspectors of factories, the age limits are 21 and 30, with an extension to 38 in favour of inspectors' assistants and of candidates who have had seven years' practical experience in a factory or workshop. Candidates must qualify in English composition and précis writing, and in arithmetic. They may also select any four in the following list of optional subjects, and must pass in three at least: 1. English literature. 2. English history. 3. General modern history. 4. French, German, or Italian. 5. Mathematics. 6. Economics and history of modern industry. 7. Chemistry. 8. Physics (including mechanics). 9. Practical mechanism and mechanical drawing.

The duties of a factory inspector are technical and fairly arduous, involving irregular hours, occasional nightwork, and a good deal of travel. They are rewarded with a salary of £200 a year, rising by £10 annually to £300, and afterwards to £450, with travelling and other allowances. There are excellent prospects of at least £550 a year, and possibilities of £750 and upwards.

Lady inspectors are admissible between the ages of 25 and 40 years. Candidates must pass an examination in English composition and arithmetic, and in three at least among a list of nine optional subjects. These include history, literature, mathematics, economics, three natural sciences, and a modern language. Successful candidates are appointed at £200 a year, with £10 increments up to £300, and a fair prospect of £100 more. Like other women civilians, they must resign their posts on marriage. The staff is a small one, and vacancies arise but seldom.

Assistants to inspectors are selected from among men with a practical knowledge of factories, and are required to pass a limited competition in simple English subjects and the elements of workshop law. The limits of age are 21 and 40. These appointments are of small value in themselves, carrying a salary of £110 a year, with £5 rises up to £150, and, on advancement to the senior grade, to £200. Their chief attraction lies in the chance they offer of obtaining a nomination for the post of inspector. There are no female assistants on the staff.

Inspectors of Mines and Quarries. For men of ability, with a sound expert knowledge of coal-mining or quarrying, and not less than 23 nor more than 35 years old, the mine inspection staff of the Home Office affords a most promising career. The nomination of the Home Secretary, which is essential for this service, is reserved for candidates holding a first-class certificate under the Coal Mines Regulation Act, who, within the past five years, have spent at least two years underground in a coal-mine. The examination scheme is simple, but includes

theoretical and practical acquaintance with coal-mines and mining, geology, mining law, and a knowledge of metalliferous mines. On appointment as junior inspector an officer receives £300 a year, rising to £450. There is a good prospect of a senior inspectorship at £500 to £700 a year.

Practical men with a sound knowledge of mining, who lack the advanced technical training expected of inspectors, may find suitable employment in the newly created grade of sub-inspectors of mines and quarries. Nominations to compete for these posts are given only to men between the ages of 30 and 40 who have had at least five years' experience in coal-mines or in quarries. The examination is of a simple character, but includes mining law and knowledge of mining or quarrying, according to the branch in which the vacancy occurs. Sub-inspectors are paid £150 a year, rising to £200. They may be specially promoted to fill inspectorships, but such advancement has been quite exceptional hitherto.

The Prison Service. The control of the English local and convict prisons is vested in the Prison Commission, a special department of the Home Office. For admission to this service the Home Secretary's nomination is imperative. It is readily accorded to suitable candidates, and should be sought by means of a printed form of application, which may be obtained from the Prison Commissioners, Home Office, S.W.

For prison clerkships the age limits prescribed are 18 and 22, but clerk warders are eligible until 30. Vacancies are filled by competitive examinations in the ordinary English subjects, bookkeeping, indexing, and digesting returns into summaries. These officers are liable to serve at any prison in England and Wales. Their pay starts at £70 and rises to £300 a year, and there are some prospects of advancement to the control of a prison.

Warders and Matrons. Candidates for subordinate positions in the English prison service are selected after passing an educational test of an elementary character. For the post of assistant warder or male nurse in a local prison, and for that of attendant in a State inebriate reformatory, the examination is in writing (including copying manuscript and spelling) and arithmetic (first four rules, money, and avoirdupois weight). The civil guard of convict prisons, and matrons and assistant matrons in all penal establishments, are examined only in reading, writing, and arithmetic (simple addition and subtraction). The holders of second-class Army certificates are exempted from these tests. The limits of age are, for male candidates, 24 and 42; and for women, 23 and 40. Applicants of either sex must be healthy, well developed, and active, of strictly sober and temperate habits, and with an unquestionably excellent character.

The minimum stature for the male staff is 5 ft. 7 in. Men who have served in the Army or Navy are readily accepted, provided their record is good. They must have obtained either "Exemplary" or "Very Good" characters on discharge, and it is officially stated that "one entry for drunkenness during the last six years of their service, and more than one such entry during any earlier service," disqualifies them from receiving an appointment. Those discharged as non-commissioned or petty officers are preferred for the local prisons and inebriate reformatories; and preference is often given to applicants with a good knowledge of some trade which they can teach if required.

Selected candidates are appointed for a year on probation, during the first four months of which term they undergo instruction in their duties, usually at a prison where there is a training school for officers.

The numbers and rates of pay of male and female warders (or matrons) are shown in the following table. In addition to the salaries there given, these officials are entitled to free quarters—or an allowance instead—uniform, and medical attendance.

PRISON WARDERS—ENGLAND AND WALES

Grade	Male		Female	
	No.	Weekly Pay	No.	Weekly Pay
In Local Prisons		£ s. d. £ s. d.		£ s. d. £ s. d.
Chief Warders ..	54	1 18 6 to 3 0 6	3	1 12 6 to 2 0 0
Principal Warders	119	1 14 0 „ 1 18 0	6	1 8 6 „ 1 12 0
Warders	1274	1 4 0 „ 1 12 0	274	0 19 0 „ 1 8 0
In Convict Prisons				
Chief Warders ..	3	2 18 6 to 3 19 0	1	1 18 0 to 2 18 6
Principal Warders	44	1 17 6 „ 2 2 0	3	1 11 0 „ 1 14 0
Warders	332	1 8 0 „ 1 16 0	15	1 0 0 „ 1 10 0

Similar conditions of employment prevail in the prison services of Scotland and Ireland, but with differing limits of age. Detailed information concerning these Scottish and Irish appointments can be had on application respectively to the Prisons Commission, Edinburgh, and the Prisons Board, the Castle, Dublin.

Clerks in the High Court. To aspirants who are debarred by their training from first-class appointments, clerkships in the Royal Courts of Justice should offer considerable attractions. The duties are light, the salaries fairly good, and the prospects excellent, while the staff is so large that from 20 to 30 v [illegible] arise every year. Candidates who [illegible] nomination for a third-class clerk[illegible] grade in which appointments are generally made—have only to pass a non-competitive test in copying manuscript, indexing, and digesting returns, in addition to ordinary English subjects. The right of nomination is vested in the Lord Chancellor, and to a lesser extent in the Lord Chief Justice, the Master of the Rolls, and the President of the Probate

Division. Persons seeking the Lord Chancellor's nomination should apply to his private secretary at the House of Lords, stating their age (which must be between 20 and 30) and their qualifications for an appointment, and enclosing copies of testimonials. From among such applicants a selection is made when a vacancy occurs. Experience as a solicitor's or barrister's clerk, and familiarity with High Court procedure, are useful recommendations for this service.

Third-class clerks in the High Court start at £100 a year, advancing by £10 yearly to £200. On entering the second class they receive £250, with £15 increments to £400; and salaries in the first class progress by £20 from £500 to £600. The proportion of superior posts is high, giving chances of further advancement.

Museum Appointments. Unlike the majority of Civil Service departments, which have little save clerical work to offer, the State museums afford thoroughly congenial employment to the student of letters, art, or science. This incentive, rather than the salaries paid, attracts to the British and the Victoria and Albert Museums men of an unusually high level of attainments, many of whom are original scientists or scholars.

Vacancies in this service are filled by limited competition. Candidates for assistantships in the Victoria and Albert Museum are nominated by the President of the Board of Education, while those seeking a post in the world-famous institution at Bloomsbury must obtain a like favour from one of its principal trustees—namely, the Lord Chancellor, the Archbishop of Canterbury, or the Speaker of the House of Commons. The age limits are, in the first case, 18 and 25; and in the other, 20 and 25.

For the British Museum, which has by far the larger staff, the examination scheme varies with the particular requirements of every section, English composition being the only "constant." In the science departments the competition rests mainly on practical and written tests in zoology, botany, geology, or mineralogy, according to the posts in view. For some branches Greek, Latin, French, and German are prescribed, in addition to a difficult antiquarian, technical, or art subject. Others exact two of the above languages supplemented by an Oriental tongue.

Candidates who pass this trying ordeal are appointed at £150 a year, rising to £500, with chances of eventually controlling a department of the British Museum at a maximum salary of £800, or of holding deputy rank at £650. Having regard to their acquirements, th figures can hardly be regarded as adequate.

The standard for entrance to the Victoria and Albert Museum is a little less severe, but includes two languages, drawing, and either an art subject or several natural sciences. These assistants are less liberally paid than their colleagues at Bloomsbury, starting with £120, and having to reach the grade of assistant keeper before they reach £500 a year.

Patent Office Examiners. The valuable post of assistant examiner in the Patent Office is readily accessible to any student between 20 and 25 years of age who possesses a thorough theoretical and practical knowledge of the physical and mechanical sciences. The work of these officers consists in examining and indexing the specifications and other documents submitted to the Patent Office by persons who are seeking patent rights. They are paid £150 a year on appointment, and receive a £15 increment yearly up to the substantial income of £450. There are also good chances of promotion to the grades of deputy-examiner and examiner, with maxima of £550 and £700 respectively.

Assistant examiners are appointed on the results of open competitions, held at intervals of about a year, for a few vacancies. The examination fee is £5. At these contests no subject is obligatory, but a candidate who failed to score fair marks—in each of the science papers at least—would have no chance of success. The syllabus includes a modern language, technical précis, mechanism, the history of inventions, and the following sciences: mechanics, chemistry, electricity and magnetism, and physics. It should be added that the chemistry required is chiefly inorganic; that the physics includes hydrostatics, heat, light, and sound, and that in these subjects and in electricity and magnetism there is a practical examination.

The Office of Woods. The open competitions occasionally held for second-class clerkships in the Office of Woods offer an assured prospect of at least £480 a year to candidates who are declared successful. Only those persons are eligible who have had three years' experience in a solicitor's office, and whose age is between 19 and 23. The examination includes the usual papers, Latin, and two important legal subjects—the elements of conveyancing and of the law of real property, especially that of landlord and tenant. Second-class clerks start at £100 a year, and rise to £350. On entering the first class they advance by £15 yearly from £360 to £480, and there are chances beyond this grade.

Insurance Commission Posts. The Health Insurance Commissions of the four countries employ a considerable outdoor staff, both male and female. These officers are appointed by individual selection, subject to their passing an educational test, but it is unlikely that the highest ranks will be filled save by the promotion of deserving subordinates. Familiarity with industrial conditions, or with friendly society or trade union work, is a useful qualification for candidates in this service; and the personal qualities most in request are a good address, tact, and the ability to write a clear report. The male staff comprises divisional inspectors (£550 to £700), inspectors (£350 to £500), assistant inspectors (£100 to £350), and Health Insurance officers (£80 to £150), members of the last grade not being eligible, as a rule, for promotion to the inspectorate. Women officers are similarly classified, but at lower salaries except in the case of

Health Insurance officers. The duties of all ranks involve constant travelling. Any application to enter the outdoor service should be made on a special form, to be obtained from the Secretary of the Commission.

The indoor staff includes women clerks, who are appointed precisely as their colleagues are in the Post Office; and female card-tellers, for whom the same examination subjects and rates of pay are prescribed as for Post Office sorters.

Labour Exchange Officers. Like inspectors under the Insurance Commission, these officials are personally selected from among likely candidates. Most of the vacancies are for men clerks, of whom "good clerical qualifications" are expected, including a knowledge of shorthand and typewriting. There are also a number of women clerks, who should know something of industrial conditions. The age limits for men are 18 and 28; for women, the upper limit is raised to 35. The salaries paid are poor, beginning at not more than £80 a year, and reaching only £150, but there are chances of being entrusted with the control of a Labour Exchange, with a stipend of £350 or £400. The women's branch also offers occasional vacancies as assistant organising officer at £150 to £200 a year, with excellent prospects of £350. Good education and organising capacity are the first essentials for this grade.

Board of Education Inspectors. The man or woman who obtains an appointment as junior inspector under the Board of Education thus secures one of the best openings that the national service offers. Unlike most Government servants, these officers are not required to pass an entrance examination of any sort. Appointments are made on the nomination of the President of the Board from among candidates who are usually university graduates in honours with a good knowledge of the theory and practice of teaching. Women must be unmarried or widows, and not less than 25 years old. For men the age restrictions are 23 and 35. It is officially notified that in the selection of inspectors weight is given to "the possession of (*a*) a university degree in honours, or other like distinction; (*b*) a university certificate or diploma in teaching; (c) the elementary teacher's certificate of the Board of Education; (*d*) qualifications in special subjects."

Candidates seeking the President's nomination should apply to the Secretary of the Board of Education, Whitehall, S.W., on a form provided for the purpose, and should accompany their application with not more than six testimonials, one or more of which should relate to their knowledge of teaching.

It is not surprising that the appointment of junior inspectors is popular with college graduates of either sex. The salary is the same for men and women—namely, £200 a year, with £15 yearly increments to £400; but whereas this represents the maximum ordinarily attainable by women inspectors, their colleagues of the sterner sex have practically assured prospects of an inspectorship at least, the reward for which is £400 a year, rising by £20 to £800. Junior inspectors are entitled to six weeks' annual leave, increased after ten years' service to eight weeks. They are allowed full travelling expenses, including second-class railway fare and a personal allowance of 15s. a night during absence from home; and their position is generally an assured and pleasant one.

Women Typists. Many Government departments now include a small permanent staff of female typists, who become entitled to the benefits of the marriage gratuity and pension schemes like other women civilians. Their pay is certainly not excessive, even in the present congested state of the feminine labour market. Starting at 20s. weekly, the typist advances by 2s. yearly to 28s., and, on promotion to the grade of superintendent, to a maximum not exceeding 40s. Beyond that figure there are no possibilities of advancement.

Candidates, whose age must be between 18 and 30, must first be nominated by the head of the department they wish to enter, and must then pass either a competitive or a merely qualifying test in writing, spelling, copying MS., simple arithmetic, and typewriting. Shorthand may be added if it is required by the office which the candidate has in view. From 100 to 150 vacancies occur yearly in the various offices. The examination fee is 1s. Typists are occasionally appointed to the Inland Revenue Office after open competition, under the same examination scheme and on the same terms as those employed in the General Post Office [see page 2305].

A Word to Students. Our survey of the home service being now concluded, we venture to add a hint or two addressed to the young aspirant for a State career who is obliged —as so many are—to enter in a subordinate grade at the outset. For such a student the importance attaching to the first two or three years of his service is incalculably great. Unless by the slow and uncertain way of promotion, it is generally during those years that he must win a higher appointment, if at all. Inability to grasp this vital fact is mainly responsible for the failures and disappointments which are frequent in this, as in every other, calling. The newly appointed civilian, confident in his abilities, suffers himself to rest on his oars a little. The months slip past unnoted, and link themselves into years—precious and irrevocable years; and when at length the effort of study is resumed, all is out of gear—the habit of strenuous work is lost, one's knowledge is dim and blurred, and the question of age limits has become suddenly menacing. So, once more, "A lost chance flies owre sea."

From this signal danger there is but one way of escape—the heroic commonplace of steadfast and unremitting toil from the moment the student gains his first footing in the service until he attains the goal of the higher appointment he covets. The man whose resolution is thus proof against the temptation to relaxed effort is the man who ultimately "arrives."

ERNEST A. CARR

The Complexity of Factors underlying Anatomical Simplicity. Synthetic Biology. Mendelism applied to Wheat-growing.

ACHIEVEMENTS OF MENDELISM

We must proceed to new considerations, which were not presented at all in Mendel's experiments, but from which his modern followers are drawing conclusions in the shape of theories and of new living varieties, which are of interest to everybody who studies modern science.

Hitherto we have assumed that any Mendelian character must be due to either the presence or the absence of a *single* factor. Typically, that is so, but this very discovery leads on to another—that there are many characters, in living species of all kinds, which need the combination of more factors than one in order to produce them. The character in question may appear to be a simple thing—as simple as the alternative tallness or shortness of Mendel's peas.

No anatomist or physiologist can detect anything but simplicity in the tiny hairs that cover the stems and the under-surface of the leaves of certain varieties of the plants called stocks. It is genetic analysis alone, as in other problems referred to in the last chapter, that enables us to discover the real genetic complexity underlying the anatomical simplicity. In the case in question, the due concurrence of three Mendelian factors is necessary before these hairs appear. This is merely one of an enormous number of instances.

Complexity in the Apparent Unit. In many of these (though not in all, as we shall most notably observe), each of the individual factors goes on its Mendelian course from generation to generation, with entire independence, as in the case of Mendel's peas. Obviously, it would be hopeless to expect that any character due to the concurrence of several factors, independent in behaviour, could be "bred true." We find that we are dealing merely with a particular combination of factors, and we can only say that, in a fixed proportion of a large number of cases, according to the laws of chance, that particular combination will recur. The character in question strikes us as a unit, but we must not expect it to behave as a unit, now that we know its real nature.

Similarly, a particular symmetrical pattern in a kaleidoscope has a real unity for the eye and the mind, but it depends upon a particular combination or arrangement of a large number of separate factors; and, once we understand the construction of the toy, we do not expect this particular pattern to recur at every turn of the tube. We know there must be recombination.

The Dangers of Analogy. Perhaps the most striking instance of the principle in question is that obtained by Bateson and Punnett, now several years ago. We quote it from an endless number because it illustrates even more than has already been said so far. Height, as in Mendel's experiments, is again in question, but we are dealing with the sweet-pea instead of the edible pea, and the reader will observe, yet again, that each genetic case must be separately studied. We cannot and must not infer, from the observed nature, the tallness and shortness in the edible pea, that the same is true even of its relative, the sweet-pea. We cannot expect identical changes.

Disappointed Expectations. Here is Bateson's own account of what he and his foremost pupil found in the latter case: "There are two dwarf varieties, one the prostrate 'Cupid,' the other the half-dwarf or 'bush' sweet-peas. Crossed together they give a cross-breed of full height. There is thus some element in the 'Cupid' which, when it meets the complementary element from the 'bush,' produces the characteristic length of the ordinary sweet-pea. We may note in passing that such a fact demonstrates at once the nature of variation and reversion. The reversion occurs because the two factors that made the *height* of the old sweet-pea again come together after being parted, and the variations by which each of the dwarfs came into existence must have taken place by the dropping out of one of these elements or of the other."

The Failure of Ancestral Inheritance. Our business here is not to detail scores of such cases, still less to attempt to memorise them (which Professor Bateson himself, it may be noted, makes no attempt to do, and which is in any case impossible); our task is to get the meaning underlying such a typical—though at first sight astonishing—case as this.

Note first that the old idea, generally held by ordinary observers, and elaborately maintained in such famous nineteenth-century generalisations as "Galton's Law of Ancestral Inheritance," is here disproved. We naturally tend to think that individuals inherit *from their parents*, and that some law must be found to represent the rule of such inheritance. "Galton's Law" asserted a mathematical ratio, and all the devoted work done since, on Galton's lines, by Professor Karl Pearson and his pupils, has concerned itself with showing how tallness and shortness, and all other characteristics, are transmitted from parents to offspring in definite proportions.

Instances of Failure. But now, when we turn from theory to experiment, mating, for instance, a dwarf and a half-dwarf—lo, a *tall* offspring! So in innumerable instances. "Galton's Law" must be abandoned, of course. That law not merely fails as a statement of fact, in such a case as this. Its underlying theory of the nature of inheritance is wrong. It assumes, as is so natural, that inheritance is from the body of

the parent to the body of the offspring. But here a dwarf and a half-dwarf body produce a tall body. Already our study of germ-cells has apprised us of the modern point of view. Inheritance is not directly from the parental body to the offspring, but from the germ-cells which the parental body contains. These germ-cells may be, and, indeed, certainly are, affected by the body which houses them, under certain conditions, but, even so, it is the state of the germ-cells, and not of the body influencing them, which matters for the offspring.

A Discarded Theory. That, then, is the first result of such an observation as this—we must abandon the idea of inheritance from the body of the parent to the offspring, and must therefore discard all theories of heredity which assume the truth of that idea. The scientific controversy in this respect has been long and bitter. In 1909 the present writer, a pupil and friend of Galton, who was then still alive, ventured to assert that eugenics must abandon its founder's "law of ancestral inheritance." That law, however, has still been appealed to as a canon of science. Its final abandonment dates from Galton Day, February 16, 1914, when Sir Francis Darwin, the famous botanist, a near relative of Galton, delivered the first Galton Anniversary Lecture, in which he declared that, in the light of modern Mendelian experiment, Galton's Law must henceforth be rejected by science. The renunciation could not conceivably have been more complete.

The Complexity of Heredity. Consider now a second, wholly different, but scarcely less important consequence of such experiments as that above quoted, and the previously cited case of the hairs upon certain stocks. These instances teach us the genetic complexity of things apparently simple. Sometimes apparent simplicity may be real, as in the tallness of the edible pea; yet similar tallness in an allied pea is as certainly dependent upon two factors, as the other upon one. Let us from this moment henceforward avoid the almost universal error of assuming the real simplicity of apparently unitary characteristics *wherever we find them.*

The simplicity may be real, but only the facts of descent, which must therefore be ascertained by experiment or observation, can prove it to be so. If this applies to the difference between tallness and shortness in the sweet-pea, and to the presence or absence of some hairs in certain stocks, what ignorant folly it is, on the one hand, to expect human genius to descend as if it were simple, or, on the other hand, to deny the laws of heredity because genius does not so descend! Yet the reader has only to dip into the modern literature of eugenics, or to recall the incessant arguments upon this subject, and the allusions to it which occur in practically every recent biography, in order to realise that the unitary or simple genetic nature of genius is assumed by nearly everybody—except those who, because it does not behave as if it depended upon a single Mendelian factor, declare that it has no natural and genetic origin whatever.

The Mixture of the Elements. The rediscovery and development of Mendelism mark a new stage in this as in so many other biological and eugenic controversies. No one who has not acquainted himself with the fundamental conceptions of Mendelism has the right to express verdicts upon heredity at all; and no one who had done so would fail to see that genius, in its many forms, is a complex. In Shakespeare's phrase, the elements are so mixed in the genius as to make him what he is. The analysis of genius, by psychology and genetics, will be a task for decades to come. When it is accomplished, we shall begin to be able to define the laws of the inheritance, not of genius as an integer, but of the factors that compose it.

An Illimitable Inquiry. Lastly, the instance of the sweet-peas offers us a new conception of the nature of the remarkable phenomenon called reversion, which Darwin and the early evolutionists of the nineteenth century so carefully but fruitlessly considered. This question, however, cannot be now discussed. We must return to it when we ask what Mendelism has done for the problem of problems—the explanation of organic evolution.

The case now considered introduces us to the idea of combining genetic factors, for the production of new forms; or for "reversion" to old ones, as the case may be. In the illustration which we have considered, the special point was the complex genetic origin of an apparently simple individual character. But there is an illimitable range of inquiry into the combination of genetic factors, quite apart from the fact that such combinations may sometimes account for simple characters in the individual. The truth is that, from the genetic point of view, we are all bundles of genetic factors; or, rather, the consequences of such factors.

Why not a Synthetic Biology? Now, our Mendelian analysis has shown that, typically, these factors behave independently in descent. Why, therefore, should it not be possible, by appropriate breeding, to construct new forms of life, in which genetic factors are combined as never before? The chemist has his synthesis, of which he is rightly proud. He takes atoms, and even molecules, or combinations of atoms, and combines these in new ways, so as to form perhaps very large molecules, unlike anything that ever existed in Nature. Such new combinations or synthetic products may be beyond price for their services to mankind, as in the case of salvarsan. That is a drug for disease. Why not a food for health, constructed by a biological instead of a chemical synthesis? In place of the atoms and molecules of the chemist, let us employ the mysterious, indescribable, invisible, yet intensely real "factors" of the Mendelian, and perhaps we shall be able to construct therewith, by appropriate breeding, new forms of life which may be beyond price as foods—not least for hungry and ever-multiplying islanders, who now grow not one-fifth of the wheat which their "hungry generations" consume.

This truly synthetic biology, as we have a perfect right to call it in analogy with synthetic chemistry, is the growing-point of the science of life at this hour. Here we shall not so much as mention the constantly increasing number of living forms thus brought into being, with the single exception of the synthetic forms of wheat now being constructed at Cambridge. These illustrate typical Mendelian principles, and no better could be chosen for the purposes of scientific exposition as such, but they stand apart for practical, urgent, transcendent national importance.

Mendelism and Wheat Growing. When the Department of Agriculture in the University of Cambridge was reorganised some years ago, a pupil of Bateson took up the work. Despite the tempting offers from abroad, he remains at his post, and the Chair of Agricultural Botany in Cambridge is already famous everywhere for the work done by its occupant, Professor Rowland Biffen. His concern is definitely practical. Research into the laws of botany as they affect agriculture is the primary object for which his Chair was founded. But abstract Mendelian theory has proved itself the most concrete and practical of realities in his hands. Ignoring other instances, let us note his attempt to construct new forms of wheat on Mendelian lines. Here the most practical of men may be reasonably expected to understand.

Analysis was the first task, exactly as in the analogous case of chemistry. Until the chemist has analysed existing compounds, and can handle their constituents accordingly, he cannot hope to build new ones. The genetic analysis of wheat occupied some years, and synthesis has since followed. Certain Canadian wheats produce the most delightful bread. The loaf is so light and well-piled that no one would now look at a loaf made solely from English wheats, which have not this power. The factor which makes Manitoban wheat so welcome upon our tables is commonly known as "strength," and it has hitherto been taken for granted that strong wheat —in this technical sense of the word—would not grow in this country.

Of course, the experiment was long ago made of growing from Canadian seeds in our soil, but the results were most disappointing, as a rule. There were a few exceptions. Says Professor Biffen : "After repeated tests of many varieties, a few have been found which consistently produce strong grain under our climatic conditions. One of the best of these is Red Fife, the wheat which forms the basis of the celebrated Manitoba Hards. This variety apparently undergoes no deterioration when grown here . . . Given proper harvest conditions, even the worst sample of Red Fife is far and away superior in quality to the best ordinary English varieties."

Synthetic Wheat. But Red Fife has an uncertain and too frequently poor yield. What is to be done ? Here is Professor Biffen's most notable answer—observe his rejection of the Darwinian principle of selection, and the dependence of his success upon Mendelian facts.

"If strong wheats are to replace the varieties we now cultivate, heavier yielding kinds than Red Fife will either have to be found or built up to suit our special requirements. The world has been ransacked to find such varieties, with such meagre results that one now despairs of finding such sorts 'ready-made.' Efforts are consequently being directed to building up suitable varieties. The methods used are dependent entirely on cross-breeding, since it is now becoming evident that no process of selection is likely to bring about the desired result.

"The solving of the problem depends upon the possibility of two distinct features —'strength' and heavy yielding capacity—being inherited, and the possibility of combining these in a new variety. A series of experiments . . . has shown that 'strength' is inheritable in its full intensity. If, for instance, a wheat of known strength is crossed with one of our weak English wheats, amongst the descendants of the hybrid plants are individuals showing the full strength of the strong parent. Further, these individuals can be fixed as definitely as the oldest wheats in cultivation, propagated year by year, and retain their strength, apparently indefinitely."

Experiments in Yield. Yielding capacity is also inherited ; and though the genetic analysis is still incomplete, several hybrids have been raised between the low-yielding—but so desirably strong—Red Fife and certain high-yielding wheats. So far—on, at any rate, the scale of the experiments now in being on the farms belonging to the Agricultural Department of Cambridge University—certain hybrids have thus been constructed, notably the wheat known as Burgoyne's Fife, which combines the strength of Red Fife with the splendid yield of its English parent, Rough Chaff.

Selection through Genetic Factors. It is easy thus, in a few bald sentences, to summarise these results of years of work, but more is already accomplished. Of course, the yield of wheat can never be too great to please the farmer, or to serve a nation's needs. On the theory of natural selection, it should be possible to increase the yield of wheat indefinitely by selection—that is, by using the seeds of individual plants whose yield is large. This method, as has already been implied, fails. Selection cannot produce in a race what was not there in the first place. Soon our hopes are cast down—the selective process effects no improvement in the yield, which fundamentally depends upon a genetic factor (or factors) which are either present or absent—" and there's an end." But the yield of wheat *could* be increased, in a practical sense, if we were able merely to stop the loss incessantly caused by the depredations of certain parasites. These losses are rarely below 5 per cent., and in some seasons rise to well over 10 per cent., of the entire crop.

Production of Immunity. Note here. finally, the sentences in which Prof. Biffen simply describes his genetic attack upon this problem, and its results. Speaking of the losses due to parasites, are largely preventible, he says :

"The heaviest of them are due to the attacks of yellow rust, a fungus closely related to the black rust which occasionally causes huge losses to the wheat-growers of Canada and Australia, and in some parts of the world makes the cultivation of the crop impracticable. Certain varieties of wheat have been found which escape yellow rust, even when grown under conditions peculiarly favourable to the parasite.

"Unfortunately, they are useless for general cultivation in this country, but, by crossing them, it has been found that the feature of immunity is heritable, and improved races of non-yellow-rusting wheats have been built up. These, after thoroughly critical testing, have been found to produce larger crops than either of the parents. For example, Square Head's Master (heavy crop, but rust-susceptible), crossed by Club (light crop, but rust-resisting), gave Little Joss, a heavy-yielding, rust-resisting wheat. This has yielded on the average more than 5 per cent. greater crops than its parent, Square Head's Master."

Infinity in Factors. Some important experiments are now in progress which Professor Biffen expects to produce still more remarkable results. Meanwhile, Burgoyne's Fife and Little Joss are practical triumphs of the application of Mendelian theory to the synthetic biology which will be the greatest triumph of all science in years to come. Historians in those days may possibly conclude that the researches of men of science, their faithful inquiry into the facts of Nature, and application of the truths thus found, were of more service to our country than the talk of politicians.

From such remarkable examples as those that have been given in this chapter, the reader who remembers our repeated observation that Mendelian factors usually behave independently in descent might assume that all things are possible—we can make any genetic combinations we please, and thus construct an infinite number of new types of plants and animals (to say nothing of eugenics) by combining any characteristics that we please. Yet if we recall Darwin's observations on the correlation of variations, or the fashion in which one character seems often to have some necessary association with another quite different character in living things, we shall see difficulties ahead. We are, in fact, limited by the inherent nature of the mysterious factors with which we are already beginning to juggle.

The Coupling and Repulsion of Factors. In the typical case, each of them descends independently, going into one germ-cell, so to say, but not into the next. But modern research has revealed numerous cases of what may be conveniently described as the *coupling of factors*, and its converse, the *repulsion of factors*. Briefly to summarise the numerous details of a case studied by Bateson and Punnett now for several years, we find that all the expected Mendelian consequences follow from the mating of a pure white sweet-pea having an erect standard, with another pure white sweet-pea having a hooded standard. The result is a purple flower with an erect standard. This colour is, by further experiments, found to be due to three factors, one for each (white) parent, which on combination produce *red*, plus a third factor from the hooded parent, which turns the red pigment purple, probably by some alkaline action such as turns red litmus paper blue in ordinary chemistry. Now, when the purple plant is allowed to fertilise itself, we get all the results we should expect, *with one exception.* We never get a *hooded red.* When the facts are fully worked out, only one interpretation of this exception is possible—the factor that makes the flower purple never goes into the same germ-cell as the factor which makes the standard erect. Between these two factors, the purpleness and the erectness of standard, antagonism or repulsion must exist.

Unexpected Correlations. An indefinite number of similar cases might be cited, both from the vegetable and the animal kingdom. And similarly there is an indefinite number of cases where factors for characters, apparently as unconnected as the colour of a flower and the form of its standard, are found by genetic analysis to be persistently coupled. If one goes into a germ-cell, so must the second, and hence it is impossible to produce an individual who possesses either character without the other.

The practical importance of coupling and repulsion of factors is immense, as we see when we remember that, for one reason or another, we may greatly desire the characters due to two factors which repel each other, or may desire a character due to one factor, and dislike that due to a second which is inevitably coupled with it. If, for instance, "strength" in wheat and susceptibility to rust were dependent upon coupled factors, even such work as Professor Biffen's would soon be brought to a standstill. Or if the red sweet-pea with the hooded standard were the only kind desired for beauty, we should have to go without.

Mendelism and Human Character. The reader will quickly reflect that there are more serious cases even than these. The novelists, the moralists, the historians, have even concerned themselves with the make-up of human character. The French, in an expressive phrase, speak of a man as having the defects of his qualities. We notice that, as the Latin poet long ago observed, people of his sort are usually irritable; the kindly are too often feeble in will; the clever too often bitter; the dominant too often brutal; the "brainy" woman unfeminine; the musician unpractical. Now, the world of life is one, and the laws of life are the laws of all life. Mendelian analysis certainly applies to some facts of the human constitution. Is there not the prospect of infinite gain, for purposes of eugenics and education, in the study of mankind from this genetic point of view?

Perhaps we shall be inclined to blame and praise less freely, to shun sex-criticism and antagonism, to "make allowances," to direct our education of the young more wisely, when we begin dimly to perceive the natural laws and limitations of our being.

C. W. SALEEBY

What a Trade-Mark is. What May and May not be Registered. How to Apply for Registration. Assignment of Trade-Marks. The Sheffield and Manchester Registries.

TRADE MARKS

ALTHOUGH in the public mind trade-marks and patents are regarded as very much the same thing, and though as a matter of convenience all things relating to the registration of trade-marks, and so on, are dealt with at the Patent Office, the two things are really quite distinct and different. While a patent protects the article itself on account of which it is taken out, and prevents others than the patentee from making such an article, the registration of a trade-mark gives no protection at all to the article, but simply accords to the person in whose favour it is registered the exclusive right to the use of the particular design or word which constitutes the trade-mark.

Trade-Mark Law Quite Modern. Trade-mark law is now of very great importance in the commercial world, and any business man whose work lies in the direction of manufacturing or selling proprietary articles should know something of the rules and regulations connected with trade-mark registration. The use of trade-marks dates back as far as the time of James I., and probably farther, but it is really only since the early part of the nineteenth century that the law relating to trade-marks has been on anything like a definite basis, and not until 1875, when the Trade Marks Registration Act was passed, was a register of trade-marks established, and registration therein regarded as constituting *prima-facie* evidence of the proprietor's exclusive right to the use of the trade-mark for the particular goods in whose class it was registered.

Designs and Words as Trade-Marks. By that Act, however, it was impossible to register as trade-marks words unless they formed part of a design or device. This, however, was remedied by the Patents, Designs, and Trade Marks Act of 1883. But as this Act left a great deal to the imagination, and to the individual opinion of the judges, by declaring that a "fancy word" might be registered as a trade-mark, the expression was altered by the Act of 1888 to "invented word."

What a Trade-Mark is. Before giving some account of the rules and regulations that control the registration of trade-marks, it is important that we should clearly understand what a trade-mark is. It is a design or word attached to the goods of a manufacturer or trader which makes it clear to the purchaser and the public that they are his produce. Any other trader may produce similar goods, provided, of course, that there is no patent connected with them, but none save the person who registered the trade-mark may use the mark, or a fraudulent "imitation" of it, in connection with the packing or sale of the goods. The functions of a trade-mark have been concisely stated as follows: "Firstly, it is a certificate of genuineness of the products to which it is affixed: this protects the public; and secondly, it is an identifying mark, owned by the manufacturer, and in the ownership of which the law protects him in order that no competitor may reap the advantage of the selling effort and advertising put forth by the owner of the trade-mark: this protects the manufacturer." Any person, whether a British subject or not, may apply to register a trade-mark in the United Kingdom, and the term "person" includes a firm, partnership, or corporate body.

Classes of Goods. There are fifty classes into which goods are divided for the purpose of trade-mark registration, and in making an application the class in which it is desired to register a mark must be stated. The classes are as follow: 1. Chemical substances used in manufactures, photography, or philosophical research, and anti-corrosives, such as acids, alkalies; artists' colours, mineral dyes, etc. 2. Chemical substances used for agricultural, horticultural, veterinary, and sanitary purposes, such as artificial manures, cattle medicines, vermin-destroyers, etc. 3. Chemical substances prepared for use in medicine and pharmacy, such as cod-liver oil, patent medicines, plasters, etc. 4. Raw or partly prepared vegetable, animal, and mineral substances used in manufactures, not included in other classes, such as resins, dyes other than mineral, tanning substances, wool, cotton, hemp, flax, jute, silk, hair, feathers, cork, coal, bone, sponge, etc. 5. Unwrought and partly wrought metals used in manufacture, such as iron, steel, lead, copper, zinc, gold ingots, iron rails, etc., armour-plates, wire, etc. 6. Machinery of all kinds, and parts of machinery, except agricultural and horticultural machines included in class 7, such as steam-engines, boilers, locomotives, sewing-machines, weighing-machines, machine tools, fire-engines, mining machinery, etc. 7. Agricultural and horticultural machinery and parts of such machinery, such as ploughs, drilling-machines, reaping-machines, threshing-machines, churns, cider-presses, chaff-cutters, etc. 8. Philosophical instruments, scientific instruments, and apparatus for useful purposes, instruments and apparatus for teaching, such as mathematical instruments, gauges, logs, spectacles, educational appliances, and so on. 9. Musical instruments. 10. Horological instruments, such as clocks, watches, chronometers, etc. 11. Instruments, apparatus, and contrivances not medicated for surgical or curative purposes, or in relation to the health of men or animals, such as bandages, lancets, etc. 12. Cutlery and edge tools, such as knives, forks,

scissors, shears, files, saws, etc. 13. Metal goods not included in other classes, such as keys, needles, hoes, shovels, anvils, corkscrews, etc. 14. Goods of precious metals (including aluminium, nickel, Britannia metal, etc.) and jewellery, and imitations of such goods and jewellery, such as clock-cases, and pencil-cases of such metals, plate and plated goods, gilt and ormolu work, etc. 15. Glass, such as window and plate glass, painted glass, glass mosaic, glass beads, etc. 16. Porcelain and earthenware, such as china, stoneware, terra cotta, tiles, bricks, etc. 17. Manufactures from mineral and other substances for building or decoration, such as cement, plaster, asphalt, etc. 18. Engineering, architectural, and building contrivances, such as diving, warming, ventilating, and filtering apparatus, lighting, and draining contrivances, electric and pneumatic bells, etc. 19. Arms, ammunition, and stores not included in class 20, such as cannon, small-arms, fowling-pieces, swords, shot, and other projectiles, camp equipage, equipments, etc. 20. Explosive substances, such as gunpowder, gun-cotton, dynamite, fog-signals, percussion caps, fireworks, cartridges, etc. 21. Naval architectural contrivances and naval equipments not included in classes 19 and 20, such as boats, anchors, chain cables, rigging, etc. 22. Carriages, such as railway carriages, waggons, railway trucks, bicycles, bath-chairs, etc. 23. (*a*) Cotton yarn, (*b*) sewing cotton. 24. Cotton piece goods of all kinds, such as cotton shirtings, longcloth, etc. 25. Cotton goods not included in classes 23, 24, or 38, such as cotton lace, braids, and tapes, etc. 26, Linen and hemp yarn and thread. 27. Linen and hemp piece goods. 28. Linen and hemp goods not included in classses 26, 27, and 50. 29. Jute yarns and tissues, and other articles made of jute not included in class 50. 30. Silk, spun, thrown, or sewing. 31. Silk piece goods. 32. Other silk goods not included in classes 30 and 31. 33. Yarns of wool, worsted, or hair. 34. Cloths and stuffs of wool, worsted, or hair. 35. Woollen and worsted and hair goods not included in classes 33 and 34. 36. Carpets, floor-cloth, and oilcloth, such as drugget, mats and matting, rugs, etc. 37. Leather, skins, unwrought and wrought, and articles made of leather not included in other classes, such as saddlery, harness, whips, portmanteaus, furs, etc. 38. Articles of clothing, such as hats, caps, bonnets, hosiery, gloves, boots and shoes, ready-made clothing, etc. 39. Paper (except paperhangings), stationery, and bookbinding, such as envelopes, sealing-wax, pens (except gold pens), ink, playing-cards, blotting-cases, copying-presses, etc. 40. Goods manufactured from indiarubber, and guttapercha, not included in other classes. 41. Furniture and upholstery, such as paperhangings, papier-mâché, mirrors, mattresses, etc. 42. Substances used as food or as ingredients in food, such as cereals, pulses, olive oil, hops, malt, dried fruits, tea, sago, salt, sugar, preserved meats, confectionery, oilcakes, pickles, vinegar, beer, clarifiers, etc. 43. Fermented liquors and spirits, such as beer, cider, wine, whisky, liqueurs, etc. 44. Mineral and aerated waters, natural and artificial, including ginger-beer. 45. Tobacco, whether manufactured or unmanufactured. 46. Seeds for agricultural or horticultural purposes. 47. Candles, common soap, detergents; illuminating, heating, or lubricating oils; matches, and starch, blue, and other preparations for laundry purposes, such as washing-powders, benzine collas, etc. 48. Perfumery (including toilet articles, preparations for the teeth and hair, and perfumed soap). 49. Games of all kinds, and sporting articles not included in other classes, such as billiard-tables, roller skates, fishing nets and lines, tops, etc. 50. Miscellaneous, including (*a*) goods manufactured from ivory, bone, or wood, not included in other classes, such as coopers' wares, etc.; (*b*) goods manufactured from straw or grass, not included in other classes; (*c*) goods manufactured from animal and vegetable substances not included in other classes; (*d*) tobacco-pipes; (*e*) umbrellas, walking-sticks, brushes and combs; (*f*) furniture-cream and plate-powder; (*g*) tarpaulins, tents, rick-cloths, rope and twine; (*h*) buttons of all kinds other than of precious metal or imitations thereof; (*j*) packing and hose of all kinds; (*k*) goods not included in the foregoing classes.

Difficulty of Selecting the Class. From this list it will be seen that there must often be great difficulty in deciding what class a particular trade-mark shall be registered under. The Registrar and his officials will always give courteous assistance in the matter, and in many cases manufacturers find that to gain adequate protection they have to register a mark in several classes.

What May Be Registered. There are a number of essential particulars which every trade-mark must contain, or consist of, if it is to be registrable. It must bear the name of a company, individual, or firm represented in a special or particular manner; or it must include the signature of the applicant for registration, or some predecessor in his business; or it must consist of an invented word or words; or it must be a word or words having no direct reference to the character or quality of the goods, and not being, according to its ordinary signification, a geographical name or surname; or, finally, it may consist of any other distinctive mark; but it must be remembered that a name, signature, or word or words other than such as falls within the previous descriptions will not be deemed a distinctive mark except by order of the Board of Trade or the court. An instance of an excellent invented word is Fruitose, which Messrs. Chivers & Sons, of Histon, have registered for a thick fruit syrup which they prepare from English fruits and pure sugar for use with puddings, etc. This is not found in any dictionary, but it conveys to the public a very good idea of the product in question. With regard to words having no direct reference to the character or quality of the goods for which the trade-mark is intended, the word "Diamond" may be cited as an example.

This has been registered in class 4 for starch, and in other classes for other articles, but it would probably not be allowed in class 15 as a trade mark for glass, being too descriptive.

According to the Act, a trade-mark may be limited in whole or in part to one or more specified colours; and in such case the fact that it is so limited shall be taken into consideration by any tribunal having to decide on the distinctive character of such trade-mark. In so far as a trade-mark is registered without limitation of colour, it shall be deemed to be registered for all colours. It must be borne in mind that it is not allowable to register as a trade-mark any matter the use of which would, by reason of its being calculated to deceive, or on any other account be disentitled to protection in a court of justice, or would be contrary to law or morality.

What May Not Be Registered. Not only is it set forth thus explicitly what may be registered, but it is equally explicitly stated that certain words and designs may not appear in any trade-mark presented for registration. It is important, therefore, that in preparing a design for registration as a trade-mark the prohibitions and restrictions should be borne in mind. They are set forth in the rules and orders respecting trade-marks as follows:

"The Registrar may refuse to accept any application upon which the following appear: (*a*) The words 'patent,' 'patented,' or 'by Royal letters patent,' 'registered,' 'registered design,' 'copyright,' 'entered at Stationers' Hall' [this is, of course, obsolete now, as the Stationers' Hall registry has been abolished], 'to counterfeit this is forgery,' or words to like effect. (*b*) Representations of their Majesties or of any member of the Royal Family."

Further, applications for registration of trade-marks consisting of or embodying the emblem of a Red Cross, the words "Red Cross," or "Geneva Cross" will be refused.

The following also are not allowed to appear on trade-marks the registration of which is applied for, unless the marks have been used since before August 13th, 1875: (*a*) The Royal arms or Royal crests, or arms or crests so nearly resembling them as to lead to mistake. (*b*) British Royal crowns. (*c*) British national flags. (*d*) The anchor devices shown on the Admiralty seal and the Admiralty flag, and devices so similar as to lead to mistake. (*e*) The words "royal," "imperial," "king's," "queen's," "crown," or any other words, letters, or devices calculated to lead persons to think that the applicant has Royal patronage or authorisation. The use of the above words in trading styles (other than the names of registered corporate bodies) will not be permitted in connection with applications for registration, unless it be shown that the sanction of the Home Secretary has been definitely obtained.

Limited and Conditional Restrictions. Apart from definite prohibitions, there are a number of conditional restrictions which the Registrar imposes, and the wisdom of which will be seen from their provisions. These are the restrictions in question:

Where representations of the arms of a foreign state or place appear on a mark, the Registrar may call for such justification as he may deem necessary for their use.

Where a representation of the arms or emblems of any city, borough, town, place, society, body corporate, or institution appears on a mark, the applicant shall, if so required, furnish the Registrar with a consent from such official as the Registrar may consider entitled to give consent to the use of such arms or emblems.

Where the names or representations of living persons appear on a trade-mark, the Registrar shall, if he so require, be furnished with consents from such persons before proceeding to register the mark. In the cases of persons recently dead, the Registrar may call for consents from their legal representatives before proceeding with registration of a trade-mark on which their names or representations appear.

Where the name or a description of any goods appears on a trade-mark, the Registrar may refuse to register such mark in respect of any goods other than the goods so named.

Where the name or description of any goods appears on a trade-mark, which name or description in use varies, the Registrar may permit the registration of the mark with the name or description upon it for goods other than those named or described, the applicant stating in his application that the name or description varies.

Ornamental or coloured groundwork, such as tartans or checks, cannot be claimed as part of a mark unless such groundwork be included within the mark by some border or lines.

Searching the Register. The first thing to do in regard to the registration of a trade-mark is to make a search in the registers at the Trade Marks branch of the Patent Office, to see whether the mark has already been registered. This applies, of course, almost exclusively to word trade-marks. There is very little formality to go through in making this search, but a fee of a shilling for every quarter of an hour is charged. If the person wishing to register a trade-mark is unable to go or send to the Patent Office himself, he may apply to the Registrar upon a specified form (T.M. No. 28), requesting that a search be made for him, and this will be done. A fee of ten shillings is charged.

Applying for Registration. If, as a result of the search, it is found that the proposed word or design has not been registered, then an application that it be put upon the register may be made. This is done upon a regular form (T.M. No. 2), which may be obtained at the Patent Office, or, by giving a few days' notice, at any money-order office in the United Kingdom. This form contains a square space to which must be affixed a representation of the proposed trade-mark, and the form must be signed by the individual making the application; or, if the applicant is a partnership firm, then one or

more members of the firm must sign it. In the case of a company applying for registration, the form has to be signed by a director or by the secretary or other principal officer of the company. An agent, however, may sign the application for registration, but before he does so the proprietor of the article must send to the Registrar an authority in writing made out on a special form (T.M. No. 1). With the application form T.M. No. 2, which has to be stamped with a ten-shilling stamp, must be sent four copies of another form (T.M. No. 3), which merely contains a square space to which has to be affixed an additional representation of the design or word that is to be registered. These forms do not have to be stamped. If it is desired to register the mark in more classes than one, then one stamped form, T.M. No. 2, and four copies of T.M. No. 3 have to be sent in for each class, applications for the registration of the same mark in different classes being treated as separate and distinct applications. All applications and communications in connection with a registration must, according to the rules, be made in the English language.

The Receipt of the Application. As soon as the Registrar receives the application he has a search made to see if there is the same or a similar mark already registered. It might be thought that this action on the part of the Registrar would make unnecessary the preliminary search by the applicant, but the value of the latter is that it prevents him expending the ten shillings for his application-form if the mark he intended applying for is already registered. The application would in that case be wasted, and the fee spent to no purpose. If the Registrar finds the mark is not already on the register, and he thinks there is no objection to it, he may accept it absolutely, or may impose conditions or modifications, all of which are communicated in writing. If, on the other hand, as a result of the search, or otherwise, the Registrar thinks there are objections to the proposed trade-mark, he will send to the applicant a statement of those objections, with a notification that unless within one month the applicant asks for a hearing, his application will be regarded as withdrawn—that is, the whole matter will be considered to have been dropped. The opportunity for a hearing within one month also holds good if the applicant objects to the conditions or modifications proposed by the Registrar.

A Hearing Before the Registrar. The Registrar having fixed a day and a time for the hearing, the applicant attends and argues his case. The objection may be, for instance, that an invented word is too much like a dictionary word, or too descriptive, for there is no fixed standard to which the applicant can work. The regulations do not allow *any* invented word to be registered as such and independent of all considerations. The acceptance or non-acceptance is in the discretion of the Registrar, subject to appeal to the Board of Trade or the High Court of Justice. If after the hearing the Registrar still objects to the registration, then the applicant may, within one month, apply upon a special form (T.M. No. 4), with a fee of ten shillings, requiring the Registrar to state in writing the grounds of his decision. This is for the purpose of appeal.

Making An Appeal. If the applicant decides to appeal he must, within one month from the Registrar's notification, send to that official in writing a case, in duplicate, stating at length the grounds upon which he relies to support his application, and whether he wishes to be heard by the Board of Trade or the High Court. Unless he does this within the specified time his application is considered as withdrawn. If he has elected to be heard by the Board of Trade, he has to send, with his statement of case, an application to be heard, made out on a special form (T.M. 10), the fee for which is twenty shillings. The Registrar forwards the case to the Board of Trade, with a copy of all the communications that have passed, and the Board then fixes a day when the applicant and the Registrar may attend and be heard. The Board of Trade will then make an order determining what conditions, if any, shall attach to the registration, or it may require the applicant to apply to the High Court within a given time. If, instead of being heard by the Board of Trade, the applicant prefers to obtain an order of the High Court, he must, within a month from the time of sending his case to the Registrar, bring the matter before the Court by motion. If his application is accepted, either by the Board or by the Court, then matters go on as if the application had been accepted by the Registrar in the first place.

Advertising an Application. When the application is accepted it is advertised by the Registrar in the "Trade Marks Journal," a weekly journal published at the Patent Office. For the purpose of the advertisement the Registrar must receive a wood-block, line-block, or electrotype of the trade-mark, whether it be a design or word, and this is printed under the heading of the class in which it is proposed to register it. The largest space available for the insertion of a block is 5½ inches broad by 7½ inches deep. Word marks must be in plain, block type. With the mark is printed the name and address of the proprietor, the kind of goods it is to be used for, and any condition or disclaimer, as, for instance, where some common word appears as part of the design. In such a case there would be an announcement, printed in italics: "No claim is made to the exclusive use of the word 'Universal' [or whatever it might be]."

Opposition to Registration. Within one month from the date when the advertisement of a trade-mark appears in the Journal, any person may give notice in writing to the Patent Office of opposition to the registration. This notice must be made at once on a form specially provided for the purpose (T.M. No. 7), and a fee of twenty shillings must be paid. The notice must give a statement of the grounds on which objection is made; and if the objection is that the proposed mark resembles trade-

marks already registered, the numbers of such marks must be set forth, and the numbers of the "Trades Marks Journal" in which they were advertised. The notice must be accompanied by a duplicate, which the Registrar can forward to the applicant.

Meeting the Opposition. Within a month of receiving such a notice of opposition, the applicant must send in a counter-statement, made out on the form T.M. No. 8, with a fee of ten shillings, setting forth the grounds on which he supports his claim against the opposition, and mentioning any of the facts in the notice of opposition which he admits. This counter-statement must also be sent in in duplicate, so that the Registrar can send a copy to the opponent. Then, within one month of his receipt of this counter-statement, the opponent must leave at the Trade Marks section of the Patent Office a declaration of the evidence with which he wishes to support his opposition, made before a justice of the peace or a commissioner for oaths, copies being provided for the applicant. Unless he leaves such evidence at the office, the opponent is regarded as having abandoned his opposition, but, if he leaves it, then within a month the applicant must in like manner leave at the office a declaration of his evidence in support of the application—copies, of course, being sent to the opponent. Within fourteen days the opponent may, if he wish, leave at the Patent Office evidence by statutory declaration in reply, but the evidence must be confined to matters strictly in reply. In all these declarations, copies or impressions of any exhibits that may be referred to must be sent to the opposite party, or, if such cannot conveniently be furnished, the originals must be sent to the Patent Office so as to be open to inspection.

The Hearing of an Opposition. All the evidence on both sides having been completed, the Registrar fixes a date for the hearing of arguments, and gives notice to the parties concerned. Within seven days of receiving this notice both parties must file Form T.M. No. 9, which is a declaration that they intend to appear, a fee of twenty shillings being required with it. If the form is not duly filed by either party within the seven days, the Registrar may take it that that party does not desire to be heard. It is in the discretion of the Registrar, however, to grant extensions of time to either party. The forms being filed, the case is heard in due course, and the Registrar gives his decision, an appeal being possible to the Board of Trade or to the High Court if the decision is contested by either applicant or opponent.

Entering a Mark on the Register. If there is no opposition when the proposed trade-mark has been advertised in the Journal, then, as soon as one month has expired, the Registrar will, upon payment of a fee of twenty shillings sent with Form T.M. No. 11—which is merely a formal note transmitting the amount —enter the trade-mark on the register. The entry will include the date of registration, the goods in respect of which it is registered, the names, address, and profession of the proprietors, with any disclaimers, conditions, and limitations, etc. When the trade-mark is actually registered, the Registrar sends to the applicant a certificate, which reads as follows: "Trade Marks Act, 1905. Certificate of Registration under Section 17. To............. I hereby certify, pursuant to Rule 67 of the Rules under the above Act, that the trade-mark in your application, No. —, was duly advertised in the 'Trade Marks Journal,' and has been registered in your name in Class —, in respect of the goods specified by you. Witness my hand, this .... day of ...., 19—." Then follows the Registrar's signature and the seal of the Patent Office. The registration is now complete, and will last for a period of fourteen years, when it may be renewed.

Renewal of a Trade Mark Registration. The application for renewal must be made on a special form, T.M. No. 72, and a fee of twenty shillings sent, not less than two months and not more than three months before the expiration of the last registration. As the proprietor of a trade-mark might forget the matter, the Registrar, if he has not received the application for renewal, will, some time between two and four weeks before the registration expires, send a note to the proprietor saying that, unless the renewal fee is paid by a certain date, the trade-mark will be removed from the register. If the fee is paid, the registration is renewed for another fourteen years; and even if the fee was not paid, and the fact is advertised in the "Trade Marks Journal," as is the custom, the Registrar may still renew the registration if the fee be paid, with an additional fee of ten shillings, within one month of the advertisement in the Journal. In this case forms T.M. No. 13 and No. 14 have to be used.

Series of Trade Marks. It is sometimes desired to register a design, as, for instance, a label for jam or pickles, in which, while the body of the design will remain the same, there will be a varying number of changes in a certain word or words, in order that the labels may be for strawberry jam, raspberry jam, plum jam, etc., or walnut, onion, cabbage pickles, etc. Or there may be a change of price or some other change in matter of a non-descriptive character. In such a case it is permitted to register all the varieties in a series in one registration, and they become associated trade-marks, which are assignable or transmissible only as a whole.

Assignment of Trade Marks. The rights in a trade-mark may in certain circumstances be transferred, but they can only be transferred with the goodwill of a business. It is important that the regulations on this point should be fully understood, as it is often supposed that a trade-mark may be assigned without any goodwill. According to the regulations:

"The Registrar may, on request made jointly by a registered proprietor of a mark and the person to whom he has assigned such mark, together with the goodwill of the business concerned in the goods for which it has been registered, register the assignee as proprietor of

the mark. Such application shall be on the Form T.M. No. 16 (a fee of twenty shillings being charged). If the Registrar so require, the assignee shall furnish a declaration on Form T.M. No. 17. Where no such joint request is made, any person who has become entitled to a registered trade-mark by assignment, transmission, or other operation of law may leave a request at the office for the entry of his name in the register as proprietor of such trade-mark. The request shall be on the Form T.M. No. 18 (the fee for which is twenty shillings), and such request shall contain the name, address, and description of the person claiming to be entitled to the trade-mark, hereinafter called the claimant. Together with such request the claimant shall leave a case stating full particulars of the assignment, transmission, or other operation of law by virtue of which he claims to be entitled to be entered in the register as proprietor of the trade-mark, so as to show the manner in which, and the person or persons to whom, the trade-mark has been assigned or transmitted, and so as to show, further, that it has been so assigned or transmitted in connection with the goodwill of the business concerned in the goods for which the trade-mark has been registered. Such request shall, in the case of an individual, be made and signed by the claimant, and in the case of a firm or partnership by one or more members of such firm or partnership, and in the case of a body corporate shall be signed by a director or by the secretary or other principal officer of such body corporate. Where the Registrar shall determine that the case sets out particulars such as entitle the claimant to be registered as proprietor of such trade-mark, he shall call upon the claimant to furnish a statutory declaration (Form T.M. No. 19) verifying the several statements in the case, and declaring that the particulars given comprise every material fact and document affecting the proprietorship of the trade-mark claimed by such request."

The Cutlers' Company. According to the Trade Marks Act, 1905, applications for the registration of trade-marks used on metal goods, if made by persons carrying on business in Hallamshire (an ancient manor, now a Parliamentary division of Yorkshire, with Sheffield for its chief town), or within six miles thereof, must be made to the Cutlers' Company of Sheffield, and left at or sent by post to the Cutlers' Hall. The fees are the same as in applications to the Registrar in London. The Cutlers' Company have to send a duplicate application to the Registrar, and he may object; but if there is no objection, the mark is advertised in the Journal, and is eventually entered in the register kept in Sheffield.

Cotton Marks. The Trade Marks Act further continues the Manchester branch of the Trade Marks Registry, and application for the registration of cotton marks has to be made to the Manchester branch, on Form Cotton No. 1, with a fee of ten shillings. As in the case of applications to the Cutlers' Company, a duplicate application form, unstamped, must be filled up, so that the Manchester branch may send a copy to the Registrar in London. The procedure is much the same as in the case of the Cutlers' Company, the cotton mark being advertised by the Manchester branch, and, if there is no objection, entered by the Keeper of Cotton Marks upon the Manchester register at the registry, 48, Royal Exchange, Manchester.

Trade Marks in the United States. The law and regulations relating to trade-mark registration are very much the same in the United States as they are here. Ownership in a trade-mark there is a property right resting in the common law, but the United States Trade Mark Law of 1905 systematised the registration of trade-marks, and provided a definite procedure for recording and protecting them.

"Registration," it has been said by an American expert on the subject, "is *prima facie* evidence of validity, but it is not conclusive evidence." The Supreme Court of the United States has declared that "the right to adopt and use a symbol or device to distinguish the goods or property made or sold by the person whose mark it is, to the exclusion of use by all other persons, has long been recognised by the common law and the Chancery Courts of England and of this country. It is a property right for the violation of which damages may be recovered in an action of law, and the continual violation of it will be enjoined by a Court of Equity with compensation for past infringements. This exclusive right was not created by the Act of Congress, and does not now depend upon it for its enforcement."

The advantages of registration, however, are great, for the owner of a registered trade-mark can, in a legal action for infringement, produce at once and without trouble the record of its adoption and legal registration. Registration in the United States Patent Office brings any litigation concerning a trade-mark within the scope of the Federal Court; whereas when a trade-mark is not registered under federal law, a suit regarding it cannot be heard in the United States Courts unless the sum in dispute is more than two thousand dollars, and the contending parties are not citizens of the same State.

International Arrangements. An International Convention for the Protection of Industrial Property exists among the principal commercial countries of the world, and under this convention an applicant for a trade-mark in any of the contracting states may obtain priority of date in any of the other states. Those who want to go into the matter of trade-marks registration in greater detail should obtain from the Trades Marks branch of the Patent Office, or through a bookseller, a number of official pamphlets, the titles of which are as follows: "Statutory Rules and Orders, 1906, No. 233." "Statutory Rules and Orders, 1912. No. 282. Amended Reprint"; "Instructions to Persons who wish to register Trade Marks"; "The Trade Marks Act, 1905"; "The Industrial Property Convention of March 20, 1883"; and "Additional Act Modifying the Convention."

CHARLES RAY

Light-Rays through Crystals. The Polariscope. Electro-magnetic Theory of Light. The Nature of a Light-Wave.

PHENOMENA OF A RAY OF LIGHT

We must now study the fashion in which certain crystals act upon a ray of light; and the point which it is desired to emphasise is that we must not regard the behaviour of solutions of tartaric acid, for instance, upon light, and the behaviour of certain crystals upon light, as unrelated, but must constantly associate them in our minds as various instances of the relations discovered as existing between light and molecules of certain shapes.

Ordinary and Extraordinary Rays. The familiar salt known as calcium carbonate occurs in great quantities in Iceland in the particular form which is known as *calcite*, or *Iceland spar*. Portions of this substance can very readily be split or cleaved so as to form a transparent crystal, having the shape of a rhomb. Now, in such a crystal there is a particular direction, which is such that the crystal is symmetrical around it, and this is known as the optic axis of a crystal. This optic axis does not pass through any point in the crystal, but, indeed, there are as many optic axes as molecules, and they are all parallel. This fact alone is proof that the behaviour of a crystal, which we are about to study, is really the behaviour of one and all of its component molecules. If we take such a crystal, and look at any object through it, we find everything is double. [See page 1937.]

In short, when a ray of light passes through a rhomb of Iceland spar, it is split up into two rays, and these two rays differ from each other in the most remarkable way. One of them is known as the *ordinary* ray; it passes through the crystal according to the ordinary laws of refraction, and displays no peculiar characters. But the other ray, which is produced by this process of *double refraction*, has some very remarkable properties of its own, and is called the *extraordinary* ray. In the first place, it does not have the ordinary index of refraction; and, in the second place, we shall find that this ray actually turns round when the crystal is turned round, in such a fashion that it always remains in the same plane with the ordinary ray, and with the optic axis of the crystal. Thus, if we look through such a crystal at writing upon a piece of paper, one of the two images of the writing produced by the double refraction actually turns round as the crystal is itself turned round.

It is essential that the Iceland spar be prepared for this purpose in a fashion which preserves its natural characters. It must be split in its three natural directions. If it be cut, we shall be apt to find that it has no peculiar characters at all, and that no double refraction is produced.

The Extraordinary Ray. What we now require is plainly some device which will enable us to study either the ordinary or the extraordinary ray by itself. This can be done by taking a crystal of Iceland spar, cutting it obliquely so as to form two wedges, and then cementing the wedges together with the substance known as Canada balsam. This particular substance is transparent, and has a refractive index which is between the refractive index of the ordinary ray and that of the extraordinary ray of Iceland spar. Hence it is an easy matter to adjust the prism— commonly called a "Nicol" —so that the ordinary ray is totally reflected from the Canada balsam (falling upon it at an angle greater than the critical angle), while the extraordinary ray passes on unchecked.

When we come to examine this extraordinary ray, we find the explanation of the fact that one of the images seen through a rhomb of Iceland spar rotates when the crystal is rotated. We find, in short, that this extraordinary ray consists of polarised light.

A Historic Observation. Double refraction had already been studied by Huygens and by Newton. It was not until 1810, more than a century after Newton's work, that, to quote Tait, "Malus, while engaged on the theory of double refraction, casually examined through a doubly refracting prism of quartz the sunlight *reflected* from the windows of the Luxembourg Palace. He was surprised to find that the two rays alternately disappeared as the prism was rotated through successive right angles; in other words, that the reflected light had acquired properties exactly corresponding to those of the rays transmitted through Iceland spar. Even Malus was so imbued with the corpuscular theory of light that he named this phenomenon 'polarisation,' holding it as inexplicable on the wave theory, and as requiring a species of polarity (akin to the magnetic) in the light corpuscles—a close reproduction of one of Newton's guesses."

It was not long before the true conception was reached: that the ethereal vibrations take place at right angles, perpendicularly to the direction of the rays. We must also note another difficulty: "That a body may transmit waves, in which the vibration is perpendicular to the direction of a ray, it must have the properties of an elastic *solid* rather than of a fluid of any kind. And our experience of the almost entire absence of resistance to the planetary motion seems, at first sight at least, altogether incompatible with the idea that the planets move in a jelly-like solid, filling all space through which light can be propagated."

The "Sides" of Light-Waves. Transverse waves, then, can have what Newton called *sides.* Furthermore, they cannot interfere with one another, so as to destroy one another, unless their "sides" are parallel; and they cannot interfere at all if their "sides" are at right angles with one another. These statements must be tested by examination of polarised light [page 1796]. But first let us insist upon the general statement of the fact, a particular instance of which was discovered by Malus.

"Light reflected from the surface of substances so different as water, glass, and polished wood, at a certain definite angle which depends upon the nature of the substance, is found to possess all the properties of one of the rays transmitted through Iceland spar." The angle thus referred to is known as the *polarising angle.* Sir David Brewster further discovered, as a result of a most prolonged and patient research, the law which goes by his name, as follows: "The tangent of the polarising angle is equal to the refractive index of the reflecting substance," or, "when the reflected ray is completely polarised, it is perpendicular to the refracted ray." The light reflected from the sky is partly polarised.

If we use two Nicol prisms together, we can obtain some very instructive results. After passing through one Nicol, light falling on another, turned at right angles to the first, is completely arrested. If a second Nicol, or "analyser," be placed in a similar position to the first, the ray passes unchanged; but as the second Nicol is rotated, more and more of the light is stopped. When the two prisms are at right angles to each other, they are opaque, even to strong sunlight.

The Polariscope. The polariscope is an instrument in which we may study the interference of polarised light. Essentially, it consists of two Nicols placed at right angles to one another, but having between them a plate of crystal cut parallel to the optic axis, and therefore capable of resolving into two—by double refraction—the polarised, or extraordinary, ray which passes through the first Nicol. In consequence of this resolution, the waves can pierce the second Nicol to some extent. In so doing, they interfere with one another, and so produce the coloured rings characteristic of the polariscope. Among other uses, the polariscope has that of enabling us to distinguish between crystals and other bodies resembling crystals.

We owe the polariscope to the discovery of Arago, made the year after the observation of Malus. He it was who first discovered that "a plate of any double-refracting crystal, such as selenite or mica, when interposed between two similar polarising prisms or piles of glass plates, displays splendid tints, varying in colour with the thickness of the plate and with its inclination to the transmitted beam, and varying in intensity as the plate of mica or selenite is turned round in its own plane." This discovery depends upon the fact, which we have already stated in other words, that two polarised rays cannot interfere with one another unless they are polarised in the same or in parallel planes. After inventing the polariscope, Arago showed by its means that the light of the sky is largely polarised (being none other than sunlight reflected from the contents of the atmosphere), and that the light of the moon and the light from tails of comets show signs of polarisation—a proof that these bodies shine by light which is borrowed or reflected. Now we turn to the greatest of the questions raised by light.

The Discoveries of Clerk-Maxwell. The discoveries of James Clerk-Maxwell (1831 to 1879), a Scotsman and the first Professor of Experimental Physics at Cambridge, have been repeatedly referred to in this course. When he was only eighteen he made two valuable contributions to physics. Not very long afterwards, he made his first contribution to electricity, which was afterwards to be the subject of his greatest work. His theory of electromagnetism, in its fully developed form, first appeared in his book "Electricity and Magnetism," which appeared in 1873, and has been described as one of the most "splendid monuments ever raised by the genius of a single individual." His name will live longest, perhaps, in virtue of his *electromagnetic theory of light* [page 742], to which some reference has already been made, when we pointed out that its author not only declared that light must exert a pressure upon surfaces opposed to it, but also dared to estimate the magnitude of that pressure—his assertion and his estimate having since been confirmed by actual observation. We may quote from Tait a very brief statement of the splendid work that Maxwell accomplished.

"Maxwell has shown how to reduce all electric and magnetic phenomena to stresses and motions of a material medium, and, as one preliminary, but excessively severe, test of the truth of his theory, has shown that (if the electromagnetic medium be that which is required for the explanation of the phenomena of light) the velocity of light *in vacuo* [in a vacuum] should be numerically the same as the ratio of the electromagnetic and electrostatic units. We do not as yet certainly know either of these quantities very exactly, but the means of the best determinations of each, separately, agree with one another more closely than do the various values of either. There seems to be no longer any possibility of doubt that Maxwell has taken the first grand step towards the discovery of the true nature of electrical phenomena. Had he done nothing but this, his fame would have been secured for all time. But, striking as it is, this forms only one small part of the contents of his truly marvellous work."

Electromagnetic Theory of Light. These words were written about a quarter of a century ago, and since then it has become possible to speak in very much bolder terms of the electromagnetic theory of light. We now know that electromagnetic disturbances are transmitted through the ether at the same speed as light, and in consequence of the work of Hertz, who approached the question from the experimental side, as Clerk-Maxwell had approached it from the theoretical side, we know that electromagnetic waves are capable of refraction and reflection, and therein follow precisely the same laws as those followed by light. Curiously enough, Hertz also was fated to die at the very height of his powers. He died in 1894, at the age of 37, and his epoch-making work was done when he was about 30, while he was acting as Professor of Physics at the Carlsruhe Polytechnic. Not only did he discover the propagation of electromagnetic waves through space, but he measured their length and velocity, demonstrated their capacity for polarisation, and the transverse character of their vibrations. In other words, he proved, to quote Helmholtz, that "light consists of electrical vibrations in an omnipresent ether which is at once an insulator and a magnetic medium." Every detail of his theories was worked out with unusual completeness.

Hertz and a New Conception of Light. Hertz was the favourite and most distinguished pupil of the illustrious Helmholtz. His work, together with that of Clerk-Maxwell, has established a new conception of light—which the nature of our sensory organs makes it difficult for us to appreciate. We must understand that light has been proved to be merely a few notes picked out for our immediate consideration, in consequence of the chemical nature of our eyes, from a great gamut of vibration with which the universe is filled; and that these vibrations are capable of interpretation in terms of electricity and magnetism.

Let us see how it affects our conception of the wave theory. The best and simplest analogy to a wave of light is to be derived from a rope attached to a hook at one end and held in the hand at the other end. To such a rope waves can readily be imparted; they seem to run along it and return. But, in point of fact, if we were to investigate the motion of any particle in the rope, we should find that it was moving up and down—in other words, at right angles to the line of propagation of the wave. Such a wave, then, would quite strictly correspond to a ray of polarised light. A ray of unpolarised light might then be conceived as consisting of the similar and simultaneous motion of an infinite or indefinite number of ropes, all vibrating about the same axis, but all in different planes.

Light a Process, not a Substance. This leads us into difficulties, because it seems quite incompatible with our notion of the ether as a continuous solid. [See page 740.] But now we must ask ourselves whether the electromagnetic theory of light does not require that we should abandon our simple physical analogies derived from ropes and the like. Probably in so doing we may rid ourselves of some contradictions. Our best plan will be to follow Maxwell himself.

In what he calls a brief summary of the evidence for the undulatory theory of light, Clerk-Maxwell first of all infers from the fact of interference that "light is not itself a substance. . . . We cannot suppose that two bodies, when put together, can annihilate each other; therefore light cannot be a substance. What we have proved is that one portion of light can be the exact opposite of another portion.

"Among physical quantities," Clerk-Maxwell proceeds, "we find some which are capable of having their signs reversed, and others which are not. Thus, a displacement in one direction is the exact opposite of an equal displacement in the opposite direction. Such quantities are the measures, not of substances, but always of processes taking place in a substance. We therefore conclude that light is not a substance, but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that, when the two portions are combined, no process goes on at all. . . . We have determined nothing as to the nature of the process. It may be a displacement, or a rotation, or an electrical disturbance—or, indeed, any physical quantity which is capable of assuming negative as well as positive values. Whatever be the nature of the process, if it is capable of being expressed by an equation of this form, the process going on at a fixed point is called a *vibration*. . . . When we contemplate the different parts of the medium as going through the same process in succession, we use the word *undulatory* to denote this character of the process, without in any way restricting its physical nature." . . .

The Nature of a Wave. The last phrase will prepare us for what we are about to see—namely, that our illustration of the rope is only an illustration. As long as our notion of a wave is derived from any of the waves we know, we shall have no choice but to think of a wave of light as a displacement—that is, as a movement of certain parts of the ether. This implies that the ether is discontinuous, and leaves us hopelessly muddled.

The original view of the wave theory was that a wave of light consists of a movement of the medium. We must abandon this altogether. Furthermore, we must abandon entirely all our preconceptions as to the meaning of the word *wave*. We must cease altogether to think of a wave of light as constituted of something which is moving up and down, or from side to side. We are very far from asserting that when we abandon this conception, as we must, we shall be able to replace it by what Descartes would have called a "clear and distinct idea" of a wave of light. But, at any rate, we shall have travelled a little nearer towards the truth.

Clerk-Maxwell points out that Faraday predicted, in a remarkable fashion, the discovery that one and the same medium is concerned in the propagation of light and in electromagnetic phenomena. "Such an action," Faraday says, "may be a function of the ether, for it is not unlikely that, if there be an ether, it should have other uses than simply the conveyance of radiation." This prediction of Faraday's has been most wonderfully verified.

The Unity of Ethereal Vibrations. Everything goes to show that the one ether is adequate, as Faraday expected, for the explanation of light and of electromagnetic phenomena. Says Clerk-Maxwell: "The properties of the electromagnetic medium are therefore, as far as we have gone, similar to those of the luminiferous medium, but the best way to compare them is to determine the velocity with which an electromagnetic disturbance would be propagated through the medium. If this should be equal to the velocity of light, we should have strong reason to believe that the two media, occupying as they do the same space, are really identical." We now know that, as Hertz proved, the two velocities are equal. Again, Clerk-Maxwell goes on to recount a number of difficulties which lie in the way of the acceptance of "the undulatory theory, in the form which treats the phenomena of light as the motion of an elastic solid." We cannot do better than quote his own words:

"The first and most important of these [difficulties] is that the theory indicates the possibility of undulations consisting of vibrations normal to the surface of the wave. The only way of accounting for the fact that the optical phenomena which would arise from these waves do not take place is to assume that the ether is incompressible.

"The next is that, whereas the phenomena of reflection are best explained on the hypothesis that the vibrations are perpendicular to the plane of polarisation, those of double refraction require us to assume that the vibrations are in that plane.

"The third is that, in order to account for the fact that in a doubly refracting crystal the velocity of rays in any principal plane and polarised in that plane is the same, we must assume certain highly artificial relations among the co-efficients of elasticity.

"*The electromagnetic theory of light satisfies all these require by the single hypothesis that the electric displacement is perpendicular to the plane of polarisation.*"

C. W. SALEEBY

Setting and Laying Footings. Plumbing the Angles. Damp Courses. Hollow Walls and Air Bricks. Corbelling and Cornices. Mortar Joints.

CONSTRUCTING BRICK WALLS

We are now in a position to consider the actual method of carrying out brickwork. The necessary excavation will have been made by the excavator and the trenches filled in to the required depth with a layer of concrete, the top of which is left level and true. The standards for the scaffold and at least one or two ledgers will have been got into position, so that the bricklayers' work, when it commences, may proceed without interruption.

Setting out the Walls. The position of the walls and their footings will have been previously marked, and the first operation will be to test the accuracy of the concrete in relation to the position of the walls, and to mark on the concrete foundations the position of the angle bricks of the footings by straining lines between the setting-out boards [see page 746]; a plummet should be dropped from their intersection and a brick accurately set on a small mortar bed to mark each angle; the dimensions should be carefully checked over again after the bricks are actually set out so that any slight inaccuracy may be corrected while this is still an easy matter.

Laying the Footings. When the setting out is verified the actual laying of bricks begins with the bottom course of footings. *Footings* consist of a base wider than the wall itself, and serve to increase its stability and to distribute its weight over the wider area of the concrete. In London, footings are required by the London Building Act, 1894, to all walls except those which rest upon girders; the minimum width of the bottom course of footings is required to be twice the width of the wall under which it occurs, and the total height of the footings is required to be, as a minimum, two-thirds of the width of the wall at its *base*—that is, at the course next above the footings. These rules are very generally accepted as the reasonable minimum requirements beyond the jurisdiction of the London Building Act. The footings of brick walls are formed of successive courses of bricks; the minimum size of each course is made one half-brick wider than the course above it, and projects beyond it 2¼ in. both in front and at the back. It will be seen, therefore, that to provide the requisite width of footings one course will be required for every half-brick in the thickness of the wall, and as the height of a brick (3 in.) is two-thirds of the width (4½ in.), this number of courses will also give the requisite height for the footings.

Bond of Footings. Footings are, with very rare exceptions, buried below the ground level, and we need not, therefore, consider the appearance of them as of such importance as to make us abandon the most suitable method of construction; whether the wall above is English or Flemish bond, the footings in all cases are laid in header bond. If the footings to a wall having a stopped end be examined [72], it will be observed that this secures a perfect system of bonding without the use of closers; for each course projects at the end of the wall 2¼ in., or the width of a closer, and also, as already pointed out, to the same extent both in front and rear, and a very thorough and complete bond results. The great advantage of using nothing but headers will be observed in looking at a cross section [73], for in each course the headers that form the front row cover the bricks below, which are also headers, to the extent of 6¾ in. by 4½ in., or three-fourths of the entire area; whereas, if the brick below were a stretcher it would be covered only to the extent of 2¼ in. by 9 in., or one half its area. And as one of the important functions of these footings is to distribute the pressure from the wall outwards, this arrangement is clearly one that will perform this duty with the least likelihood of producing a fracture. It is, however, obvious that, as the width of the footings increases by only a half-brick in each course, a single course of stretchers must be used in every alternate course; but, excepting in the case of the first course of footings to a one-brick wall, this never shows on either face, but is placed at or near the centre of the wall. It should be so arranged that two successive courses of stretchers do not come vertically one above the other [see the section, 73]. Where a wall is not stopped, but is returned, the angle brick in each course must show as a stretcher in the return wall, but immediately beyond this brick the use of headers is resumed [83].

Double Course of Footings. It is a useful practice to build the lowest course of footings two bricks high [78], and this should invariably be done if circumstances permit of the concrete bed being omitted. This is sometimes done for all courses [78] where the loads are heavy and the foundations deep enough; but though advantageous when great strength in the footings is required, this doubles the depth of the footings and naturally adds to the cost. Any course of footings that is formed with two courses of bricks will show ordinary English bond, a course of headers above a course of stretchers on the face.

Marking the Line of Footings. In laying the bricks after the angles have been fixed a line is stretched to mark the inner and outer face of the wall; this is fixed at each end to an iron spindle having a blunt blade. The

line can be wound round the spindle to shorten it, or unwound to lengthen it, as required, and the blade is inserted into a joint; this line is tightly strained, and marks the level of the top of the course. When these preparations have been made a layer of mortar is spread upon the concrete bed which, if it has got thoroughly dry, should be first wetted, to prevent undue absorption of the water in the mortar. Starting from the angle brick, some mortar will be plastered on the side of it, and the next brick will be laid on the mortar bed a short distance from its final position and then moved into position, thus forcing up a little mortar into the vertical joint.

The front row of bricks on each face is first completed, and, when it comes to filling in the last brick before the next angle is reached, a little mortar is usually spread on it to form the last vertical joint. This outer row of bricks is carefully adjusted to the line, and may be tested with a level [**34**, page 2459]. The bricks are knocked down to their proper level with the side or with the butt-end of the handle of the trowel. The outer line of bricks being carefully placed, the filling in may proceed much more rapidly, as the same care in aligning the bricks is not necessary.

Flushing up the Joints. When the course is complete it will be found that the vertical joints on the face are filled, but that many of the other vertical joints are still open. Mortar is spread over the top of the course and worked into these joints with the trowel, and it is important that these joints should be well filled to ensure the full strength of the wall being attained and, in the case of walls above the ground level, to prevent rain being driven through the walls at imperfect joints. This process is described as *flushing up.*

The next course of footings is set out in a similar manner, being formed one-quarter brick within the line of the first until the top course of footings is completed.

Beginning the Wall. The next course of bricks forms the *base* of the wall, and at this point a slight variation in procedure begins. The courses are no longer diminished in width, but the wall is continued upwards of the same thickness for at least several feet, and the bonding has to receive attention. Instead of setting a single angle-brick the angle of the wall is raised for several courses at a time [**84**], and is very carefully put together. Such an angle is usually formed so as to extend at the base for a length of two or three bricks in each direction, each successive course being reduced in length as required by the bond.

Plumbing the Angles. At the angle the plumb rule is used on both the front and the return face to ensure that the quoin, or angle, is perfectly vertical. The plummet consists of a straight-edge with parallel sides [**33**, p. 2459], and with a fine line or groove marked on the face. At the top are two or three fine slits, by means of which a line may be readily attached and adjusted. This line carries a heavy plummet of lead at its lower end. In using this instrument one edge is placed in contact with the wall to be tested, the face of the straight-edge is inclined slightly forward, the side being still in contact with the wall, so that the line and plummet swings out a little from the straight-edge. If, when it is allowed to swing back, it falls so as to coincide with the line, it shows the edge, and, therefore, the wall with which it is in contact, to be truly vertical; if it is not so, the bricks must be adjusted until this result is obtained on both faces. When two angles have thus been built, the line is strained through for each course, and the wall between the angles is brought up to the height to which the angles have been built, when the process is again repeated.

Building to a Fair Face. The process of forming the face of a wall carefully in this manner, so that all the exposed faces of the bricks are in an even plane, is termed building to a *fair face.* Such a length of wall is usually worked from the two ends towards the centre and from both faces, one bricklayer standing outside, the other inside, the wall, unless overhand work has to be resorted to. [See page 1534.]

Keeping Perpendiculars. Owing to the slight irregularities in the sizes of bricks, and to the possibility of slight unevenness in the thickness of vertical mortar joints, it happens, even where bond is properly formed, that unless special care be taken the vertical joints in one header course, for example, will not coincide precisely, though they will approximately, with those two, four, six or more courses below. There may be no such discrepancy as to interfere with the soundness of the wall, but its smart and workmanlike appearance is affected, and in all high-class work the bricklayer is expected to see that *perpends are truly kept* [**46**, page 1534]. This necessitates that from its base, or, at least, from any plinth course, the bricklayer must set out all openings that may occur in the upper part of the wall; where these involve forming small piers with, perhaps, the introduction of a header in alternate stretcher courses to give the required dimension to the pier. This treatment must be followed in the lower part of the wall before the window openings are reached. The closers for bonding the small intermediate piers do not appear in the unbroken wall below the level of the openings, but all other perpends should be carried down. If two successive storeys in a building are separated by a moulded string or projecting band, the line of perpends may be interrupted at such points if necessary.

Thickness of Walls and Reducing the Thickness. In constructing a high wall comprising several storeys it is not necessary to carry it up of uniform thickness throughout. In London the minimum thickness of any wall at its base and the extent to which the thickness of upper storeys may be reduced is regulated by the London Building Act, 1894, Schedule 1. The thickness at different levels depends partly upon the class of structure, partly upon the height, and partly upon the

length. These schedules give all necessary particulars, and though the regulations are not binding, except in London, they serve as a useful guide for reference in other districts in which such particulars are not prescribed by the local building regulations.

The external face of a wall is, as a rule, built throughout in the same plane, but where the thickness of the wall may be decreased it is done by omitting at definite stages one half-brick of the thickness [85]. Such a reduction is termed a *set-off*, and in most cases occurs on the inner face at a point where a floor is to be carried, advantage being taken of the ledge formed by the set-off to support the floor. In the case of a party wall this reduction is made on each side and amounts to 2¼ in. Sometimes, for convenience of carrying the lowest floor of a building, a set-off is required just above the base of the wall, and to form this an extra half brick is added to it at the base; but if this be done it is not necessary to increase the width of the footings; this thickening ranks merely as extra brickwork to carry the floor, and is built up so as to include in its thickness the two top courses of footings [72].

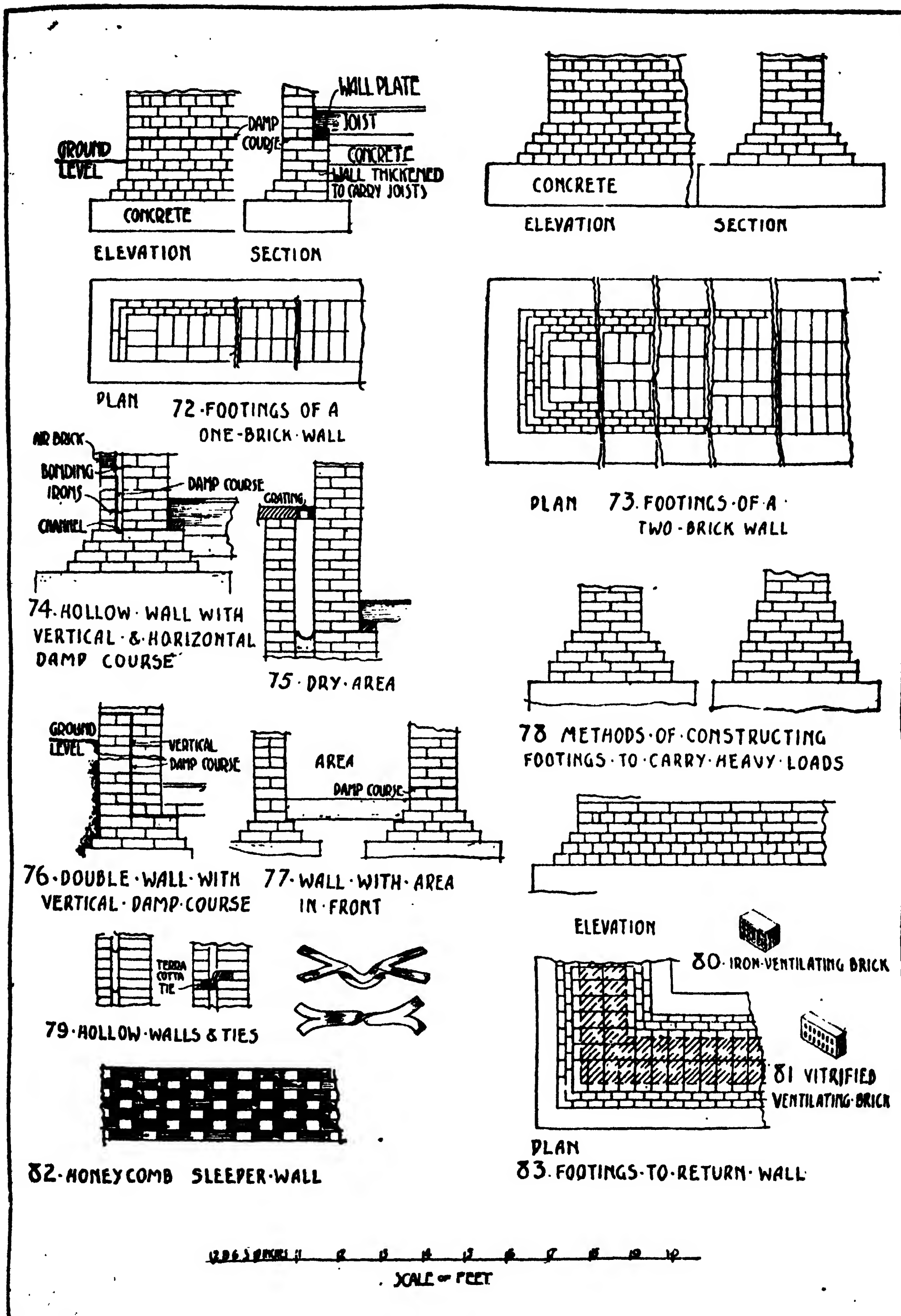
Sleeper and Fender Walls. It is often convenient and economical to form dwarf walls between the main walls to help to support the lowest floor, and such walls are termed *sleeper walls*, because they carry a wood sleeper or plate, which in turn carries the floor joists. Such walls may be a brick or half a brick thick, and will require footings. They are often formed as *honeycomb walls* [82]—*i.e.*, every course is formed, not by laying the bricks so that the ends are joined together by a mortar joint, but by merely bedding the bricks in mortar with a considerable interval between the ends; stretchers only are used. The objects of this construction are partly economy of material, but mainly the promotion of free ventilation below the floor level; such a wall is, of course, less strong than an ordinary wall, but it is amply strong for a low wall subjected only to a vertical load; it is rarely more than eight or ten courses high. *Fender walls* are usually one-brick walls built in front of a fireplace on the lowest storey, to carry the hearth-stone and the floor joists.

Damp Courses. At some point above the base of the wall and below the level of the lowest floor it is necessary to insert in all walls, including sleeper walls, a layer of impervious material to prevent moisture from rising in the walls. The footings, and perhaps the wall itself for some height, are usually in contact with the soil, and, being absorbent, will take up moisture from it; and this will, if not interrupted, tend to spread upwards and render the brickwork damp. This layer of material is termed a *damp course*, and, obviously, must, to be effective, be placed at such a level that at no point above it will the natural earth be in contact with the wall. The wall is carried up to the required height, and finished off with a level surface to receive the damp course, which may be of various materials.

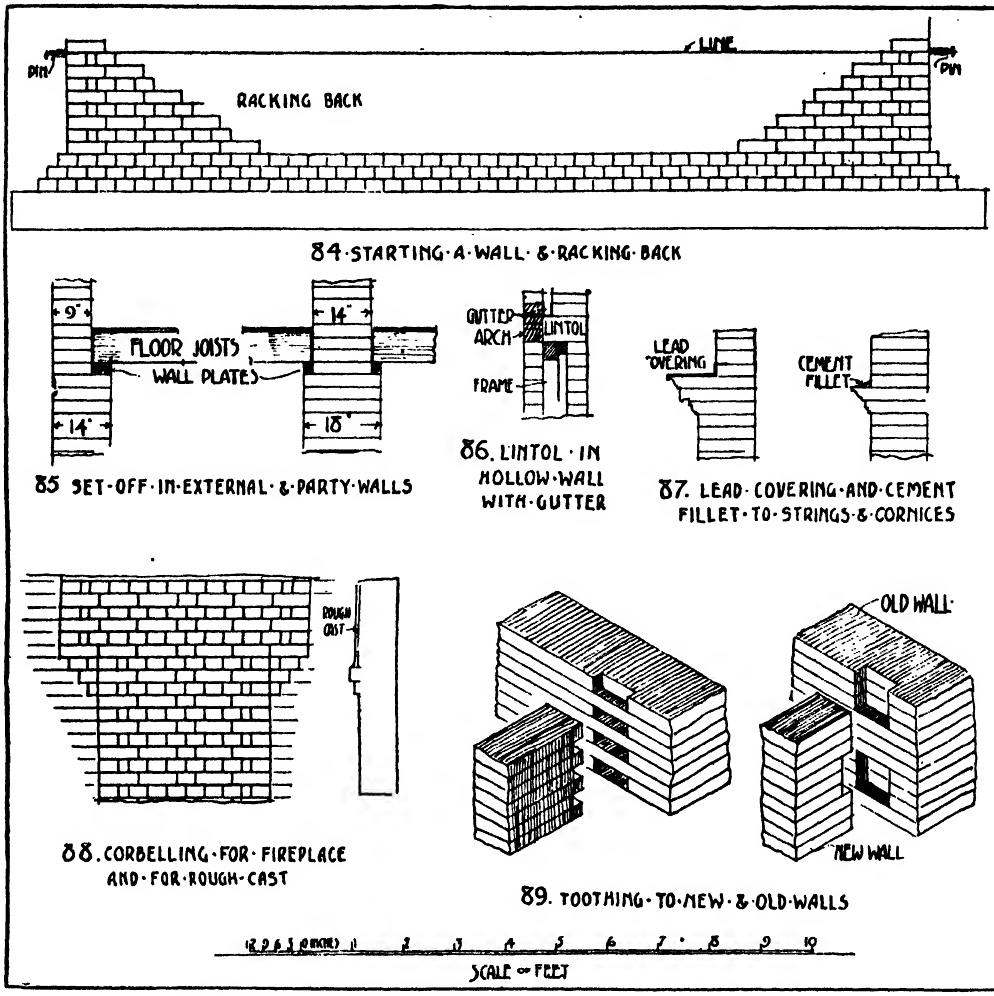
Mineral Asphalt Damp Course. Probably the very best material in the British climate consists of a layer of *mineral asphalt* ½ in. thick. The only possible drawback to this material is that, if subjected to a high temperature, it may soften and ooze out under the pressure of the walls above it. It is laid in the following manner. For the best work, after the brickwork is levelled, the mortar or cement should be allowed to get fairly dry; thin slips of wood are fixed on each side of the wall, so as to stand ½ in. above the bed; the asphalt is melted in a cauldron, and becomes semi-liquid, and is then, while still hot, poured over the wall and the top is levelled; the material cools rapidly and becomes hard. It should not be laid on wet mortar, as steam is apt to be generated, and small bubbles formed. The wood edges are not always used; the material is so thick that it can be worked up to the edge as it cools without running over, but there is more liability to unevenness in thickness. One great advantage of this material is that should there be any change in the level of the damp-proof course, it may easily be worked on to the vertical surface between such different levels.

Other Damp Courses and Materials. Salt-glazed *stoneware blocks* are made in widths of 9 in. and 13½ in., and from 1½ to 3 in. in thickness. They form an excellent damp course, and are especially useful for inserting in an existing wall; they are frequently perforated, and then serve as ventilating gratings also. They should be bedded and jointed in Portland cement and sand; and it is useful to build all work up to the damp-course level in cement mortar. *Bituminous sheets*, made with refined bitumen, form a damp course which is durable, flexible, and is made in various thicknesses from ⅛ of an inch upwards, and of suitable widths for ordinary walls. One form is made of two layers of bitumen with a thin sheet of "laminated lead" between. *Sheet lead* is sometimes used as a damp course bedded in and covered by a layer of cement. One of the most usual forms, and a very economical and serviceable one, consists of two layers of good, impervious roofing slates laid on and between cement beds, and so placed that the joints in one course of slate break joint with the other course. Any of these are reliable, but care should be taken after they are laid to protect them till they are covered with brickwork. A mixture of tar and sand is sometimes used, but is liable to soften and squeeze out if the wall is exposed to sunshine even in this climate. Felt is quite unreliable as a damp course; after a time, if constantly subjected to the action of moisture, it is likely to perish.

Floors Below the Ground Level. It not infrequently happens that it is necessary to place the lowest floor of a building below the level of the ground surrounding it. When this has to be done the best course is to provide outside the wall an open area 3 ft. wide or more if possible [77], so that the wall is nowhere in contact with the surrounding earth. The level of the floor of this area must be taken down sufficiently low to bring it below the level of the



72-83. FOOTINGS, DAMP COURSES, HOLLOW WALLS, AND TIES



84-89. DETAILS ILLUSTRATING THE CONSTRUCTION OF WALLS

damp course. But in many cases circumstances do not permit of this treatment, and some other means must be adopted.

A *dry area* [75] is sometimes formed by building a thin outer wall 4 in. or more from the main wall; the bottom is carried down below the level of the damp course, and provided with a channel or drain to dispose of any moisture that soaks in through the outer wall; the top is covered with stone slabs or brick arching, and openings are left at intervals to provide ventilation to the space between the two walls. The outer wall may absorb moisture from the soil and become wet, but the damp cannot pass directly to the inner wall; such a narrow area is difficult of access, and not entirely satisfactory. Where no open or dry area can be formed, a damp course placed above the ground level, though it will keep the walls above dry, will not protect the lower part of the walls, and in such a case there must be a second damp course below the floor level, and provision must also be made for preventing moisture soaking into the wall between these levels.

Vertical Damp Course. A vertical damp course may be formed by covering, or *rendering*, the outer face of the wall with a layer of Portland cement and sand about an inch thick, or covering it with asphalt, which is best put on in two rather thin coats, say ⅜ in. each. A better plan still is to provide such a layer of asphalt in the thickness of the wall, where it forms a vertical damp course and is secure from any damage or interference [76]. This involves a straight joint in the thickness of the wall; but the disadvantages of this may be obviated by the use of bonding irons or ties to bind the two thicknesses together. The best method is to build one part of the wall first, building in the iron ties, which are galvanised, at intervals of 1 ft. 6 in. in every fourth course; the face of the wall is then covered with asphalt, leaving the outer end of the irons protruding from the face, and these are built in to the other

thickness of the wall as it goes up. Such a wall is perfectly sound and entirely proof against damp, even in the case where the ground is actually waterlogged, and may be used in forming storage tanks for water.

Another method is to build the two parts of this wall with a considerable cavity, say 1½ or 2 in., and to fill in this cavity with such a material as hygienic rock, which is a damp-proof material somewhat similar to asphalt; it is filled in hot into the cavity, and is impervious. If this be done the operation should be carried out at intervals of about four courses; if the cavity be allowed to become deeper than this before it is filled in, there is some risk of air bubbles being formed in the material, which may then fail to keep out moisture.

Hollow Walls. For buildings of a small class, walls of one brick thick are allowed by law and are sufficiently strong; but they are not thick enough in an exposed situation to keep out wet if accompanied by driving wind. In some situations even a brick-and-a-half wall built in cement will hardly do so. For such positions hollow walls are frequently employed; these are formed throughout their height of two walls of brickwork, between which is a cavity varying from 1½ in. to 3 in. [**79**]. In some rural districts walls are permitted to be built 9 in. thick in this way, the bricks being used on edge instead of flat, and built as Flemish bond, the headers forming the tie between the inner and outer skins of brick. Such a wall is ugly in appearance, but would be likely to resist the weather better than an ordinary one-brick wall. As a rule, such a wall would not be allowed in any urban district, certainly not in London, and is, in any case, only suitable for work of no great height and requiring no great strength. As a rule, a hollow wall is built with an inner thickness of at least one brick and an outer thickness of at least a half brick, and the two are bonded together at regular intervals by some special form of tie.

Wall Ties. These may be of glazed terra-cotta [**79**] or glazed earthenware, and are of such a form that the inner end is built 4½ in. into the inner wall, corresponding in height with an ordinary brick course, while the outer end is built into the outer wall at a level one course lower down. This form is adopted to ensure that, if any water should be driven through the outer thickness and reach the bonding brick, it shall be thrown back against the outer wall and not reach the inner one. The outer end, if it be built into a half-brick wall, is made only 2¼ in. long, and will have a quarter-bat in front of it to correspond with the wall facing. A cheaper and more usual form of tie is made of galvanised iron, cast or wrought; the latter are the better. They are made with fangs at each end for building into the two walls, and the part corresponding to the hollow space is formed with a dip or twist to ensure that any water will drop from it and not pass across the tie to the inner wall.

Constructing the Hollow Wall. Such a hollow wall should start from the level of the damp course or below it and extend above the top ceiling. A channel should be provided at the bottom to carry off any water collecting in the hollow [**74**], and great care must be exercised to see that in building the walls the mortar is not allowed to drop into and choke this channel or to lodge upon the ties; it is best to have openings in the outer wall at intervals at the level of the channel so that it may have any such mortar droppings removed on the completion of the wall.

Air Bricks. Ventilation must be provided to this space by means of air bricks built at intervals into the outer wall near the bottom of it and also near the top; these are usually 9 in. by 3 in., or 9 in. by 6 in., and may be made of brick earth, with a series of perforations passing right through, to allow of the passage of air, or they may be of cast iron. In the latter case they consist of a cast iron box of the thickness of half a brick, with an external plate of iron perforated to admit air [**80** and **81**].

Openings in Hollow Walls. When openings for doors or windows occur in such a hollow wall, the hollow space may be stopped at the jamb with narrow slates set in cement; wherever the heads of timber frames or wood or concrete lintels run across the hollow, the upper surface must be protected by a small gutter of lead or zinc turned into a joint in the outer wall and long enough to project beyond both ends of the member to be protected, so that any water may be discharged into the hollow space clear of any timber [**86**].

Upper Part of a Wall. In constructing a wall, the outer face is generally a perpendicular one, and is built throughout in a single plane, but there are likely to be, at certain points, various departures from this plane face. In the first place, just above the ground level, the face of this wall is sometimes set back, not by means of an offset, but by means of a moulded or splayed surface. Such a projection at the base of the wall is termed a plinth, and in a brick wall is usually 2¼ in. or 4½ in., but sometimes much more. This moulded face may be of brick, or of stone, or terra-cotta [**13**, page 2456; and **70**, page 2597], and, in any case, is built into the wall as the work goes up; if stone or terra-cotta be used, the course must be arranged to bond with the brickwork, as already described.

Forming String Courses. At higher points in the wall, bands of mouldings, termed string courses, may be built in so as to project beyond the face of the wall, and may be of brick, stone, or terra-cotta, arranged so as to bond with the brickwork. In addition, it usually happens that the upper surface of such a string course, if it be of brick, will be horizontal, and as there will be many joints, water is likely to lie in the top and find its way in. To obviate this, either the top is covered by a strip of lead, turned up against the wall above and into a brick joint, or the surface is covered with a layer of Portland cement mixed with sand, the upper surface of which is inclined, or *weathered*, so as to throw any water away from the wall; this is termed a *weather fillet* [**87**]. Any horizontal

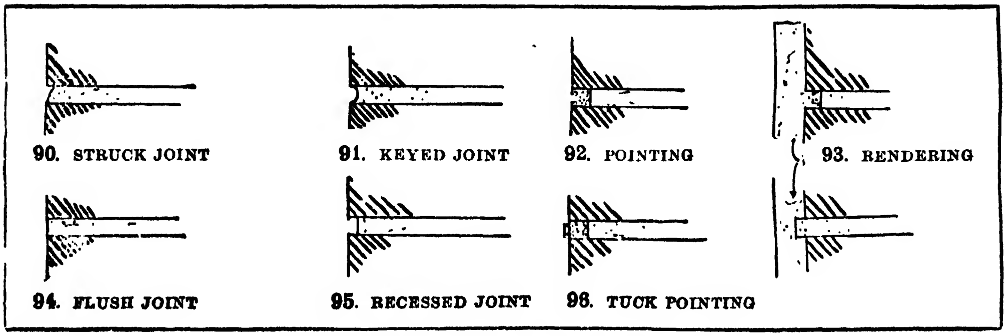
upper surface of brickwork that has to be formed should be so protected.

Corbelling. It may often happen that it is desired to project a portion of the upper part of a wall beyond the lower so that its face overhangs the lower part of the wall—*e.g.*, such a projection is often formed to provide the extra thickness required to form the fireplace and flues of an upper storey. This may be done in brickwork by *corbelling* or *oversailing* [88], which consists in projecting successive courses of brickwork so that the face of each slightly overhangs the face of the course below—exactly reversing the arrangements of footings. No single course should project more than 2¼ in. beyond the course below it, and for many purposes a projection of 1⅛ in. is more satisfactory. In the former case, four courses, and in the latter eight courses, will give a projection of 9 in.

In cases where the upper part of a wall is to be rough cast or hung with tiles, the lower part of this wall is usually finished with two or more courses of corbelling so as to throw out the lower edge of the tiling or rough cast [88]. Such a corbel course may be formed of plain or moulded bricks, or of a mixture of plain and moulded bricks. Where each course projects 2¼ in., it is desirable to use header bond, but with a projection of 1⅛ in. stretcher courses may be used.

Cornices. Sometimes at or near the top of a wall a large and elaborate group of mouldings is corbelled out from its face, and in this position the term *cornice* is given to such a feature, which is an architectural enrichment, and not essential to the structure [87]. Such a cornice may be formed of brick, and will include courses of plain as well as moulded, and very possibly enriched bricks. When formed of such small material, great care is required in putting together such a cornice, the corbelling out of which must be carefully done. The upper surface must be protected by leadwork or cement, and the wall is often carried up beyond the top of the cornice, forming a blocking course, to counteract the tendency of such a feature to overbalance. Any cornice of brick must be designed to be of only a moderate projection, and cannot overhang to the extent that is possible with one formed of long stones.

Protecting the Top of a Wall. The top of any wall requires some special care to ensure that water shall not lie upon it and soak into it. In some buildings the top of the wall is completely covered by the roof which overhangs it, and so far as protecting the wall is concerned, no better plan is possible. But in towns such an overhanging roof is often not permissible, and the roof must finish behind the wall, or, if it covers part of the wall, a thickness equal to one brick at least, is carried up, and is termed a *parapet* [16, page 2457]. In either case the top must be protected so that rain falling upon it will not soak in. An inexpensive and effectual method is by forming a *tile creasing* at the top. This consists of laying on the upper surface of the wall two or more layers of hard, impervious roofing tiles so as to overhang both faces of the wall. These are laid in cement, so as to break joint, and, in fact, form a damp course at the top of the wall; they are usually finished by a course of plain or bull-nose or half-round bricks set on edge and built in cement. Such a course of bricks forming the termination of a wall is termed a *coping course.*



90-96. METHODS OF FORMING BRICK JOINTS

Special Copings. For rather better work brick or terra-cotta copings of special design [17, page 2457] are made in large blocks so as to reduce the number of joints, and so as to overhang both faces of the wall, and a hollow should be formed in the under surface of such a coping block on both sides of the wall, so that any water running from the upper surface shall drip from the edge of the coping and fall clear of the wall, and not drip down the face of it; such a hollow is called a *throat.*

Copings are made in a great variety of forms and widths to suit different styles of architectural treatment and individual tastes. In some the water is thrown off one edge of this coping, which is then styled a *weathered coping;* or, if a plain surface be formed to throw the water off both edges, it is termed a *saddle-back coping,* and others are termed *moulded copings.*

Finish to Ramps and Sloping Surfaces. A curved surface forming the top of a wall in such a feature as a ramp must have the bricks cut to the required form, but is usually finished with a coping of brick on edge which, if the curves are sharp, must be axed. This is to avoid finishing the top of a wall with small pieces of cut brick, which would easily be displaced, and the cut surfaces of which would be

particularly liable to absorb moisture. Where the width of an external feature, such as a chimney stack, requires to be reduced, simple offsets are both ugly and unsuitable, and such reductions may be made by forming a double slope across the thickness of the wall with a small gable covered with tiling or a coping, or by a single slope finished by what is described as *tumbling;* this consists of a series of brick courses set at right angles to the slope, and the lower surfaces cut to fit on to a horizontal bed, the object being, as in the case of a ramp, to show only whole bricks on the exposed surface.

Effect of Heat on Brickwork. If brickwork be executed in very dry or hot weather the bricks themselves will be dry; if laid in this condition they are likely to absorb the water from the mortar to such an extent as to interfere with the action of setting, and at such times the bricks should be well wetted before use. This is best done with a hose before they are carried to the scaffold.

Effect of Frost on Brickwork. Brickwork in mortar should not be executed during the prevalence of frosty weather, the danger being that the water in the mortar will be liable to freeze. In Norway it is held that with due precautions brickwork may be safely carried on when the thermometer stands at 14° to 18° F., and even when it is as low as 0° F., but that it ceases to be economical when the temperature is below about 14° F.

At these temperatures work is executed with mortar mixed with quite freshly-slaked lime made in small quantities and used while still hot, and the proportion of lime is increased as the temperature becomes lower, so that setting may take place before freezing. The bricks must be quite dry when used. Bricks exposed to rain or frost must not be employed, and after any temporary stoppage of work the top of any piece of brickwork must be cleared of any ice or snow before work proceeds. When the frost is not severe, work may usually be carried on in cases where a quick-setting cement is used.

The top of a wall may be protected during frosty weather by covering it with felt or sacks and boards; the mortar joints may be affected for some little distance into the wall, and must be then raked out and pointed, but if the damage extends far into the wall the only remedy is to take down and reinstate the work.

Finishing Mortar Joints. The mortar joints on the face of the wall may be finished in various ways, but they are rarely left just as they are formed in laying the bricks. If the surface of the wall is to be plastered or rendered [93], the mortar in both horizontal and vertical joints is raked out for a depth of about ⅜ in.: this is to give a better hold or *key* to the plaster. If the face of the wall is to remain exposed, the joints are carefully finished, and this process greatly improves the appearance of the brickwork. If the weather be suitable, this may be executed as the work proceeds, and the joints are then said to be *struck* [90]; if the work is of such a nature that it can be completed in this way without fear of frost, it gives good results. Where frosts may be expected to occur before the walling is complete, it is usual to rake out the joints to a depth of about ⅜ in. as the wall is built, and to finish the whole face of the wall when completed, and this process is termed *pointing* [92]; it involves reinstating the stages on the scaffold to carry out the work better than is necessary for merely making good the putlog holes, and the work must be well wetted before pointing. In the case of old walls, in which the mortar joints show signs of decay on the surface, this method is always employed.

The actual finish of the face may be made in a variety of ways, and many of these may be used whether the joints are struck or pointed. The joints are actually formed with the trowel. A special small trowel is sometimes used, and a long straight-edge.

Flat, or Flush Joints. *Flat,* or *flush* joints [94] are those in which the mortar is flush with the face of the wall and vertical; this is sometimes varied by leaving a line drawn along the centre of the joints by means of an iron jointer.

Struck Joints. *Struck* joints [90] are formed with an inclined face; the lower edge is flush with the brick below and is struck with the trowel and straight-edge; the upper edge is pressed back so that any water dripping from the brick above will be thrown off by this surface on to the face of the brick below; this form of joint is sometimes described as a *weathered joint.*

Keyed joints [91] are formed by drawing a rounded iron along the centre of a flush joint, giving it a hollow section.

A *recessed* joint [95] is formed by setting back the face of the mortar behind the face of the brick: but this is not so good a protection to the wall as a weathered joint.

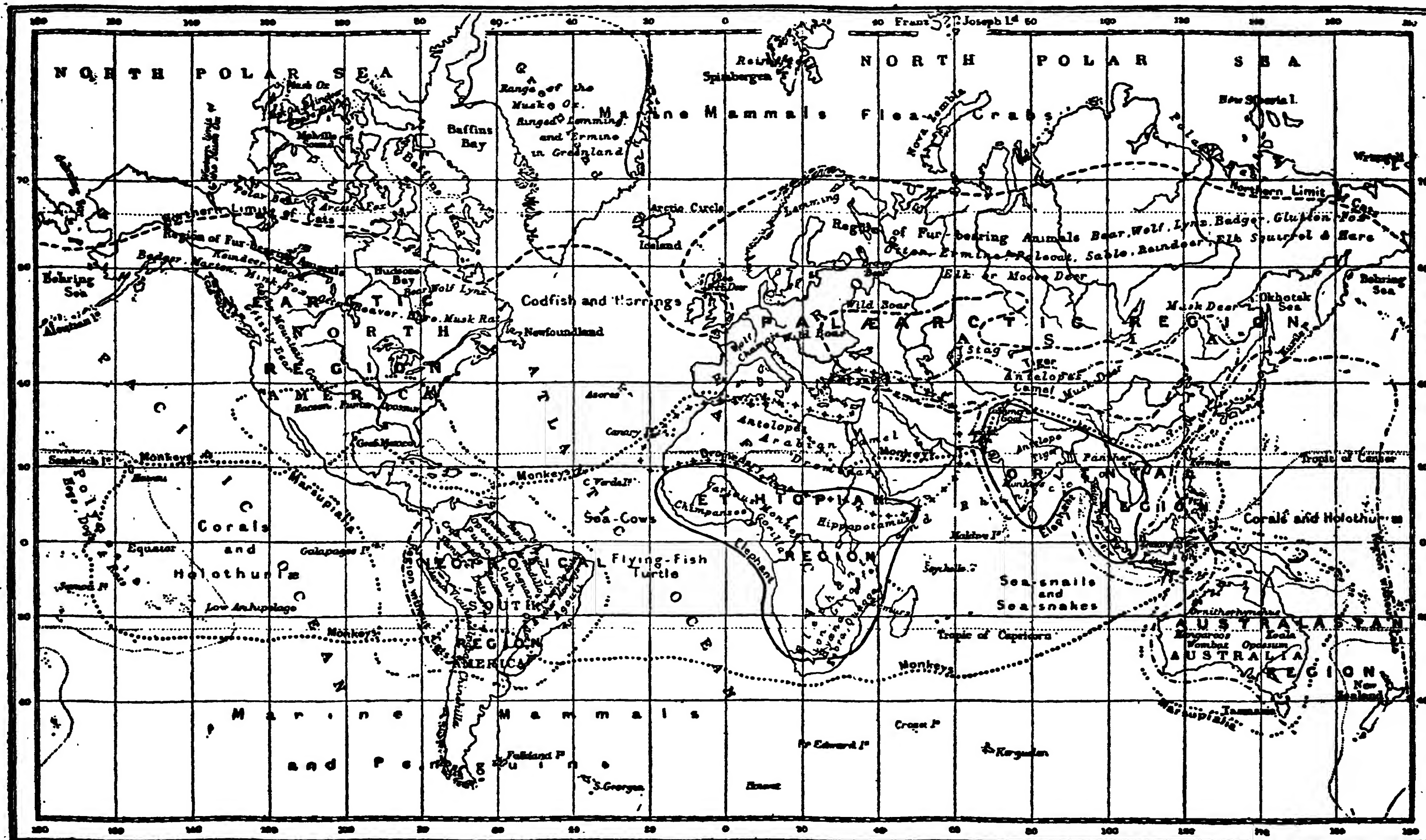
Tuck pointing [96] is generally used to conceal the defects of inferior work. The joint is filled flush with mortar; the wall is then rubbed down with a soft brick, so that the bricks and mortar are of a uniform colour, or a wash of ochre is sometimes applied; finally, a fine line of white putty is worked on to the centre of the surface of the joint, so as to give the appearance of gauged work.

Forming Toothings. If for any reason a cross-wall cannot be built at the same time as the main wall from which it starts, a *toothing* is formed in the main wall—*i.e.*, in every alternate course a recess the full width of the cross-wall and 2¼ in. deep is formed by building in the closers used to bind the cross-wall only. This allows of the cross-wall being properly bonded to the main wall when it is built, but unless the walls are built in cement the main wall will have settled down slightly before the cross-wall is erected, and this, too, when built will in time settle down also, and a fracture at the joint may result.

If a new wall has to be bonded to an old one it is usual to cut out toothings the full thickness of the new wall three or four courses high, and penetrating 4½ inches into the old wall, and to build the new work into them.

R. ELSEY SMITH

THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS OVER THE SURFACE OF THE GLOBE



This map, following suggestions of Dr. P. L. Sclater and Dr. Alfred Russel Wallace, shows the six regions into which the animal life of the world has been grouped, namely, the Palæarctic, or Old World, with Northern Africa; the Oriental, or India and the East Indies; the Australian, including the Pacific; the Ethiopian of Central and South Africa; the Neotropical of South America and the West Indies; and the Nearctic of North America.

How Wild Life Has Been Distributed over the World from the Earliest Ages

GEOGRAPHY OF THE ANIMAL WORLD

There is probably no branch of natural history about which so little information is given in popular works as that which discusses, and very largely explains, the causes of the varied and apparently erratic distribution of animals. Yet there is none which is so puzzling or so interesting. This is partly due to the fact that the complete explanation is not only fundamentally based upon the laws of evolution, but that it requires also a frequent reference to the facts of geology, and to recent discoveries in physical geography.

Darwin laid the foundations of the study by his observations and deductions as to the total absence of both mammalia and amphibia from oceanic islands, and by his extensive experiments and observations on the modes of dispersal of organisms; and it is only by combining these sources of recent knowledge with information regarding the nature of deep-sea deposits that an intelligible view has been attained.

First let us state briefly some of the curious facts and apparent anomalies that have to be explained. Why, for example, are camels found only in the great desert-belt of North Africa and Central Asia, and their nearest allies, the llamas and alpacas, only in the southern Andes?

Curiosities of Animal Distribution. The old idea that animals are found where the conditions are suitable is disproved by the fact that the entire horse tribe is now limited, in a wild state, to Africa and Asia, but when introduced into both North and South America by the Spanish conquerors they ran wild and increased enormously. Most extraordinary is the case of the curious tapirs, of which two or three species are found in tropical America, and the only other species—the Malayan tapir—in Borneo and the Malay Peninsula. Among birds we have the humming-birds swarming all over America, but in no other part of the world. The equally wonderful birds of paradise, of which about fifty different species are now known, are found only in New Guinea and a few adjacent islands. Lastly, we have the great mammalian order of Marsupials, limited to Australia and the adjacent islands, except that one family, the opossums, abounds in South America and as far north as California and Virginia.

We may also look at these differences from another point of view—that of the similarity of the animals in countries far apart, and the diversity that is often found between those which are comparatively near together.

If a person travels from England to Japan or the Amur, he will have gone very nearly half round the globe to find in the forms of life a wonderful similarity to those of his native land. But if a settler in Australia goes to New Zealand, a distance of about 1300 miles, he finds himself in a country zoologically and botanically entirely unlike the country he has left.

Even more remarkable is the case of two small islands, Bali and Lombok, in the Malay Archipelago, only fifteen miles apart, yet strangely different in their productions. Their birds differ more than do those of Britain and Japan. Again, the great island of Borneo is much more like Sumatra and the Malay Peninsula, both in its mammals and birds, than is the much nearer island of Celebes, whose productions are more nearly allied to those of India or Africa.

Now, these and most of the other peculiarities in the distribution of animals are either directly explained or rendered intelligible by the application of general principles, and I therefore propose now to explain the nature of those principles.

Permanence of Oceanic and Continental Areas. I begin with what is perhaps the most fundamental and far-reaching of the phenomena on which the interpretation of the existing distribution of plants and animals depends, the true importance of which was first perceived by Darwin.

Before the "Origin of Species" appeared, the common belief was that almost all the islands scattered over the great oceans were the remnants of former continents which had sunk beneath the waters, while our existing continents rose up to take their place. This view was accepted almost as a matter of course, and seemed, at first sight, to be quite in accordance with the fact that most of the older rocks in all parts of the world were of marine origin. But, during the voyage of the "Beagle," Darwin was able to visit many of these islands, and he was struck by the poverty of their forms of life. He also noticed that all of them were either volcanic or of coral nature, and they never contained any of the stratified rocks characteristic of continents and of islands that have once formed parts of them. He therefore concluded that they had all been formed in the ocean itself, though some of them appeared to be very ancient; and the total absence of native land mammals could thus be easily explained, as these animals, though often good swimmers, could never cross wide seas or oceans. He further showed by experiment that the eggs of batrachians (frogs, newts, and the like), which were also wanting, were quickly killed by salt water.

Some years later, when electric cables began to be laid across the oceans in various directions, and when the voyage of the "Challenger" showed us the contour of the ocean floor and the nature of its deposits, a striking confirmation of Darwin's views was obtained. For it was then

shown that the floor of the great oceans did not form hills and valleys and mountain ranges, as had often been assumed, but was really an enormous, slightly undulating plain at a depth of from ten to thirty thousand feet, out of which plain the continents and islands usually rose abruptly, so that the 100-fathom line closely approached their shores, and even the 1000-fathom line only left a narrow belt around them, in no way altering their general outline.

Existing Continents and their Probable Extensions. If we look at a globe or a map of the world in hemispheres, and consider the position of the continents and larger land masses, we find that they, even at the present time, are wonderfully connected; that it would be actually possible for a man to traverse the whole of the continents, starting from Cape Horn, without ever going out of sight of land or requiring any other vessel than a small open sailing-boat. If we now look at a map showing the 1000-fathom line around all the continents, and taking this as roughly indicating the amount of extension of the land during the whole Tertiary period of geology, we shall find all the continents united towards the north by wide stretches of land, offering ample facilities for the migrations of land animals at successive epochs.

Warmer Climates in Past Geological Periods. But there is another consideration which is continually left out of account by those who still claim direct land connections to account for real or supposed affinities of the extinct animals of South America and South Africa, and that is the much warmer climate that prevailed in northern and Arctic regions throughout Tertiary times, and even very much earlier.

This is proved by abundant remains of fossil plants found in Miocene strata all round and within the Arctic Circle, and of such a character as now grow a long way further south. On the west coast of Greenland, in 70° N., are beautifully preserved specimens of such trees as chestnuts, sassafras, oaks, planes, beeches, plums, vines, and even a magnolia, all closely resembling trees and shrubs which now grow 20° or 30° farther south in North America. Even so far north as Spitzbergen, one of the most barren and most inhospitable regions on the globe, a rich fossil flora has been found, indicating a climate fully as mild as that of the warmer parts of Canada at the present time, comprising such familiar plants as hazel, ash, and walnut, with water-lilies and an iris. As there was probably continuous land between Europe, America, and Asia, at least as low as the latitude of Stockholm, while the land a little further south had a warm temperate climate, it became possible for every kind of mammal of the temperate zones and many of the tropics to pass from continent to continent.

Power of Dispersal of Animals. The distribution of animals, of course, depends in part upon their individual powers of locomotion, but this is by no means the only factor of importance in determining their actual habitations, and is often entirely neutralised by other causes. In most continents, and in many of the larger countries or islands, birds exhibit a very similar restricted range to mammals, notwithstanding their very superior powers of locomotion. Reptiles also exhibit little difference in this respect, except that they are more dependent on temperature, and become scarce in temperate and almost absent from very cold countries. The amphibia—frogs, toads, newts, salamanders—are in some respects more restricted than reptiles in their ranges, and more extended in others. This is due to the fact that they can withstand a lower temperature, their eggs being often frozen without injury, but, on the other hand, they are killed by salt water, and this explains the interesting fact that they, as well as mammals, are wholly absent from all true oceanic islands.

Floating Trees as Distributors. This class of islands may be defined as being situated in the great oceans far from any extensive land masses, and being surrounded by depths of more than a thousand fathoms. All such islands are entirely without any of the older stratified rocks, and consist either of volcanic rocks or of coral formations which have been deposited upon them. Such are the Azores, Madeira, St. Helena, Mauritius, and all the remoter islands of the Pacific Ocean, none of which possesses either mammalia or frogs, and the most remote from land no reptiles nor fresh-water fishes. These are entirely absent from the Azores and St. Helena, while the Sandwich Islands possess two lizards—one very widespread over the whole western Pacific, and therefore presumably conveyed accidentally in canoes; the other a peculiar gecko, whose ancestors were probably introduced at some remote epoch by exceptionally favourable circumstances, such as large floating trees from more westerly islands.

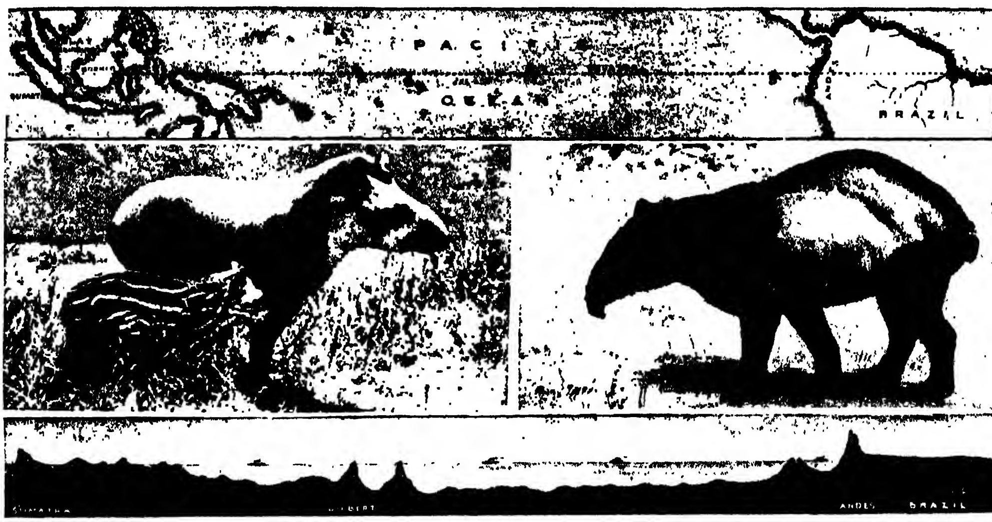
Within the tropics especially, masses of trees and floating vegetation are often carried out to sea, and under favourable conditions may be driven by winds and currents for many hundreds or even thousands of miles, and carry with them small lizards or their eggs, insects, and land shells. These latter often hide in crevices or under bark, while some snails, when dormant, will stand immersion in salt water for twenty days without injury. We thus see an explanation of the curious fact that in the remotest islands, even when every kind of vertebrate except birds is absent, a few land shells and terrestrial insects, especially beetles, are always to be found.

500 Kinds of Shells. But the more remote the island, and the rarer the chances that bring these later creatures to it, the more peculiar we find the existing species to be. Thus, in the very remote Sandwich Islands, with their rich vegetation and favourable climate, there are about 500 different kinds of land shells, almost the whole of which are peculiar species; and the moderately rich insect fauna is equally peculiar. In the Azores, however, which are less remote from the nearest continent, and much more subject to violent storms—bringing numerous birds which are both seed and shell carriers—shells and insects are less numerous, and a much larger proportion belong to European forms.

The Distribution of Tapirs. One of the most prominent of the puzzles of distribution to the earlier naturalists was that of the tapirs, the two commonest species of which inhabit tropical South America from Brazil to Paraguay, and the Malay Peninsula, Sumatra, and Borneo. Three other species also inhabit tropical America, one in the high Andes and two in Central America from Panama to Mexico, but none is found either in Africa or continental India.

But the course of geological discovery during the nineteenth century completely explained this apparent anomaly. First, in 1825, Cuvier described the skeleton of the Palæotherium from the early Tertiary beds of Paris as being allied to the living tapirs; and later, both in France and Germany, the remains of true tapirs were found in the middle Tertiary (Miocene) and late Tertiary (Pliocene) strata, both in France and England, and fossil tapirs have been found in China, and in America from Carolina to California, and of no other parts of the world. But in the Andes and temperate plains of South America is a group of small animals—the llamas, alpacas, and guanacos—which in all essentials of structure, even to the peculiar complex stomach adapted for water-storage, belong to the camel tribe. These two allied groups are, therefore, now almost as remote from each other as are the American and Malayan tapirs, with no allies whatever in intervening regions. But here, too, geology has furnished the solution. First, in the late Tertiary deposits of the Siwalik hills of North-west India remains of true camels have been found; and a wonderful series of fossils has been discovered in North America, in late, middle, and early Tertiary strata, by which the whole gradual development of camels from a smaller and more primitive type has been exhibited with a remarkable consistency.

The same strata have shown us early forms combining the characters of all the hoofed



TYPES OF THE TAPIR AS THEY ARE FOUND IN THE EAST INDIES AND IN BRAZIL

The present distribution of the tapir shows that it must have passed on foot, by land that was continuous, no doubt by way of Australia, between the Western and the Eastern worlds.

Now, always keeping in mind the extreme imperfection of the geological record, these discoveries clearly indicate that many species of tapirs inhabited warm and temperate Asia, Europe, and North America in middle and late Tertiary times. But during these epochs warm and even sub-tropical conditions prevailed in the Northern hemisphere as far as the Arctic Circle, accompanied by an abundant and luxuriant vegetation; and we have also seen that these conditions were probably brought about, in part, by a greater extension of land in the North Atlantic, admitting of more or less easy communication between the Eastern and Western hemispheres. The problem of the tapirs is therefore completely solved.

Dispersal of the Camel Tribe. The case of the camel is perhaps even more interesting than that of the tapirs, which it somewhat resembles. Camels are now inhabitants of the desert regions of Western Asia and North Africa, animals, from the swine and the hippopotamus to camels, cattle, deer, sheep, and antelopes, gradually becoming specialised into those varied forms. It is therefore clear that in all probability the camel and llama tribes originated in the Central United States, where, towards the end of the Tertiary period, they became extinct. Previous to this catastrophe, however, some of the true camels migrated to the Eastern hemisphere, probably by the way of continuous land in the North Pacific, and have left as their survivors the camel and dromedary in the highlands and deserts of Asia.

About the same time, and probably driven to migrate by the same adverse conditions which led to the extinction of so many of their allies, the llama group passed southwards along the central mountain ranges into South America, where they have found suitable conditions for their survival south of the Equator, in the high Andes, and on the arid plains of Patagonia.

The Spread of the Horse Tribe. The horses, asses, and zebras constitute a distinct and very remarkable tribe of mammals, being the only members of that great class which possess a single functional toe on all four feet. These animals are now strictly limited in a wild state to Africa and Western Asia, though in quite recent times they ranged over Europe and the British Islands; and many allied groups are found in still earlier times, back to the early Tertiary, showing the gradual transformation of a four-toed animal of small size, step by step, into the true one-toed horse.

But, what is more curious still, a similar and even more complete series of ancestral forms existed in North America, where the true horse was also developed, its fossilised remains being found over both North and South America nearly up to the Glacial period. Then suddenly all became extinct. But after the great Ice Age had gone, with the many changes of animal life that accompanied it, the two continents again became well adapted to horse life.

It is curious that the series of these ancestral horses runs almost parallel in America and Europe, though the species are not exactly the same; and this seems to imply that the North Atlantic land connection existed for a long period, and that inter-communication from America to Europe and from Europe to America frequently occurred. It is, in fact, difficult to tell in which continent the true horses now living actually originated. In both there was an animal about the size of a fox, which seems to be the earliest direct ancestor of the modern horses and asses. This intermingling of the ancestral forms of a group so well adapted for migration, both in structure and habits, renders it certain that such connecting lands and such mild climates as are indicated by other evidence really existed throughout a considerable part of the Tertiary period.

Elephants and Their Ancestors. The elephants are of special interest, for two reasons. Their distribution in middle and late Tertiary times was very similar to that of the horses, and they disappeared from America, Europe, and Northern Asia at as late, or even later, a period, and with equal suddenness. The huge mammoth, with its enormous curved tusks, lived in Northern Europe and Asia, as well as in North America, down to the human period. Many other species are of late Tertiary date, and died out a little earlier; and among these were some curious pigmy elephants from three to five feet high, whose remains are found in the caves of Malta and Cyprus.

None of these numerous forms gives any clue to the early stages of the elephant type so strikingly different from all other mammalia. But remarkable discoveries have now been made in the early Tertiary beds of the Fayum valley, in Middle Egypt, of an interesting group of fossils of mammals which are believed to be the ancestral forms of the entire elephant tribe. The earliest of these is an animal not very different from the ancestral swine and tapirs, but of very small comparative size.

The Division of the Globe into Zoological Regions. In order to describe and compare the distribution of the various species, genera, and families of animals, it has been found necessary to mark out a certain number of extensive areas characterised by distinctive forms of animal life. The older naturalists usually adopted the great geographical and racial divisions—Europe, Asia, Africa, America (North and South), and Australia; or the still broader Arctic, temperate, and tropical regions. They also used the general term "India or the Indies" for all Eastern tropical lands, sometimes including all the tropics, as in our still common but misleading term "West Indies."

The first thoroughly scientific attempt to establish a series of regions that should accurately summarise the main facts for any extensive class of animals was made by Dr. P. L. Sclater. in 1857, for the class of birds, at that time, as it is now, probably the best known of all the more extensive groups of animals. He was the first to point out that Europe and Asia do not correspond to primary divisions of animal life, as shown by the striking similarity and considerable identity of both the birds and mammals across the whole of Europe and temperate Asia.

Groups Irrespective of Continents. This formed his first great region, which he termed the "Palæarctic," as including all Old World northern lands. Then came the tropical portion of Asia, which possessed hosts of altogether peculiar species, genera, and whole families of birds not known in the temperate zone. This he termed the "Indian Region," because India, in a wide sense, formed the bulk of it. This term, in my "Geographical Distribution of Animals," I altered to "Oriental Region"—perhaps unnecessarily—because it included Burma, Siam, and all the great Malay islands, and this name has been widely adopted.

It may be mentioned that the Palæarctic Region also included North Africa as far as the Sahara, all its chief productions, both animals and plants, being closely allied to those of Europe or Western Asia. The remainder of Africa, possessing a large proportion of peculiar types, and being thoroughly isolated from the rest of the world, constituted the "Ethiopian Region." The fourth was the "Australian Region," perfectly characterised by its very peculiar marsupial mammals, as well as an immense number of peculiar genera, and of several remarkable families of birds. The eastern half of the Malay Archipelago belongs to it, as do also New Zealand and most of the Pacific islands. Then came South America, including the West Indies and Central America as far as Mexico, forming the "Neotropical Region," because it included the whole tropics of the New World. Temperate and Arctic North America constitute the "Nearctic Region" of Dr. Sclater. It has relations with both the Neotropical and Palæarctic regions, but has sufficient special features to be kept distinct.

ALFRED RUSSEL WALLACE

The Laws of Electric Heating. Calculation of Heat Radiation. Electric Radiators. Electricity in the Kitchen. Electric Cooking.

ELECTRIC HEATING

As has been pointed out in the course of these chapters, whenever an electric current is forced through an imperfect conductor—that is, through a conductor which offers a resistance to the flow of electricity—the energy expended on forcing the current through the conductor is transmuted into heat. The conductor, in fact, is warmed or heated by the current that passes through it, the energy of the current being more or less frittered away, as by a sort of internal friction, according to the resistance of the conductor.

Simple Experiments on Electric Heating. Every glow lamp gives an example of the heating of a conductor (the filament inside the lamp bulb) by the passage of a current through it. Whenever any wire is too thin properly to carry the current that is transmitted through it, that wire becomes hot, even red-hot if the current be strong enough, or it may even be melted. If water slightly acidulated be placed in a U-tube and a current sent through it by means of a metallic rod inserted in the limbs of the tube, and joined to a battery or to a dynamo, the water is rapidly heated.

The greater the resistance of any conductor through which a given current is sent, the greater is the heating. Thin wires resist more than thick wires of the same material. If, therefore, a chain is made in which the alternate links consist of thin copper wire and thick copper wire, and a current is sent through the chain, the thin links will be found to heat up more than the thick ones. In this experiment the current should be gradually increased by the use of a few cells at first, and a larger number afterwards, until the thin links glow red-hot, illustrating the principle of the greater resistance of the worse conductor. Another variety of experiment is to make a chain of pieces of equal thickness of copper wire and iron wire. As iron resists (for an equal thickness and length) about six times as much as copper, the iron links will be found to heat up red-hot as the current is increased, while the copper links remain cool.

Laws of Electric Heating. The evolution of heat in an electric resistance is governed by certain definite laws. They are different according to whether we are dealing with a case in which the energy is supplied at a constant voltage or with one in which there is a given number of amperes of current.

Calculation of Heat Radiation. The heat developed per second in a resistance *varies inversely as the resistance.* As heat is formed of energy, the rate at which heat is developed can be expressed in watts [see page 234]. The rule is that the number of watts produced in heating a resistance is proportional to the square of the voltage of the supply, and inversely proportional to the resistance of the conductor that is heated. Suppose, for example, that we have a conductor (of wire or carbon) the resistance of which is 40 ohms, and it is supplied with current at a voltage of 100 volts, then the heat energy will be radiated from it with a constant value of $100 \times 100 \div 40 = 250$ watts. The current through the conductor will, of course, be $100 \div 40 = 2{\cdot}5$ amperes.

If we were to substitute a conductor of double the resistance, the amount of heat-radiation would be reduced to one half, or 125 watts. But if the electric energy were supplied at double the pressure, the heat-radiation in the 40-ohm conductor would be increased fourfold, for then we should have $200 \times 200 \div 40 = 1000$ watts. In fact, the rule may be put into symbols as:

$$W = V^2 \div R \qquad (1)$$

where W is the number of watts that are being developed, V the voltage of supply, and R the number of ohms of resistance of the conductor.

Another way of calculating the number of watts thus given out in heating is to calculate the current in amperes by Ohm's law [page 627] and then to multiply this by the voltage, as:

$$W = I \times V \qquad (2)$$

Yet another way is to calculate the current, square the number of amperes so found, and then multiply the resistance. Thus, in the above case, where a current of 2·5 amperes was sent through a resistance of 40 ohms, we may calculate as follows:

$$2{\cdot}5 \times 2{\cdot}5 \times 40 = 250 \text{ watts.}$$

In this law the formula becomes:

$$W = I^2 \times R. \qquad (3)$$

In this last form the rule is known as Joule's law, in honour of Dr. Joule, who discovered that the heating effect in a given resistance is proporti nal to the square of the current. But it is less useful in present calculations than the first rule, because the current is not a fixed quantity but depends on the resistance used.

Electric Radiators. Various methods of electric heating are now coming into domestic use. Fig. 222 shows the familiar lamp radiator. This radiator contains four large carbon filament lamps. These lamps are purposely made to give out as little light and as much heat as possible, so that, if looked at from the light-giving standpoint, they are as bad as possible. They give about 15-20 c.p., and consume 250 watts, so that a 200-volt lamp takes about 1¼ amperes, and four lamps take 1 K.W.

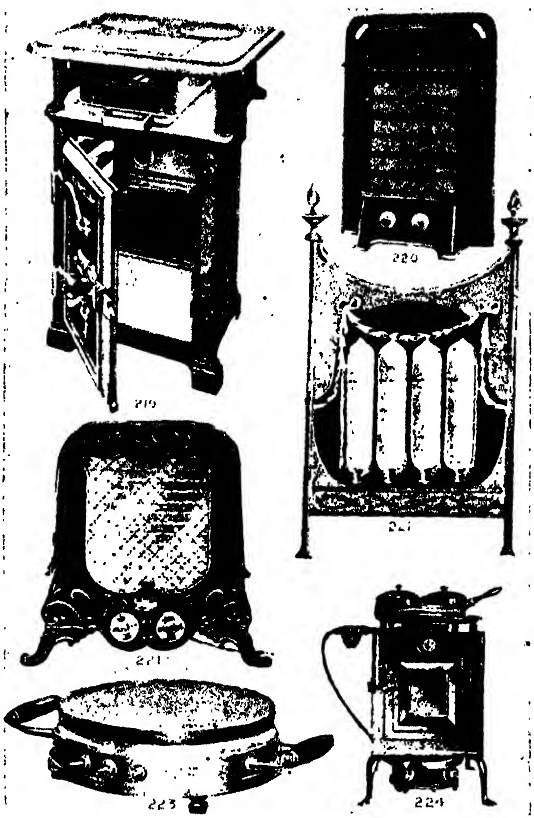
Many undertakings supply energy for heating purposes at 1d. per B.O.T. unit, which means that four lamps can be kept alight for one hour for this sum, or two lamps for two hours. These radiators give out part of their energy as

conductive heat for the lamp, and the frame itself becomes to a certain extent warm, and so directly warms the room, but the greater part is radiant heat—hence the name. Radiant heat—like sunlight—gives the sensation of warmth without heating the intervening medium. Glow-lamp radiators look and feel very cheerful, and if kept on a sufficiently long time they sensibly raise the temperature of the room. It is usual to allow one watt of electric power per 1 cubic foot of space in the room.

Figs. 220 and 221 are typical of another class of radiators. These consist of coils of wire which are heated to low incandescence in air. They radiate heat to a small extent, and the dull glow gives a certain appearance of comfort, but the greater part of their heat is conductive, or convective—that is, is imparted directly to the air. The Bastian radiator has the wire inside a quartz tube; the Belling fire has the wires wound on infusible porcelain or stoneware supports. Another type of radiator or convector has a number of wire coils, which are heated to a point a little below incandescence. The heat in all such cases is given out by convection, or conduction, not by radiation, and in order to give the appearance of warmth a red lamp is often placed in the connector.

Efficiency of Radiators. As regards efficiency, there is really little to choose between the various types. For long-continued use the convector is probably the best, but for convenience—especially in rooms only occasionally used—the lamp radiator is a great favourite. In the Ferranti fire the coils of wire are placed behind a quartz or silica plate, which it heats to incandescence. This heated plate is surrounded with a copper bowl as a reflector, producing a very pleasing and, indeed, artistic effect.

Domestic Irons. A further popular domestic application of electric heating methods is to the iron. The heating element consists of fine wire of special composition wound either on insulating formers or on mica strips. These wire coils are placed near the iron base, but separated from it by insulating material. When the current is turned on, the resistance wire becomes hot first, and then communicates its heat to the iron. Many thousands of these self-contained irons are in use, and in laundries and factories they find an extended application, in many cases entirely replacing gas. Soldering irons are made on the same principle, and in a number of difficult cases these, too, have proved satisfactory.



219. ELECTRIC COOKER. 220. BELLING ELECTRIC FIRE. 221. BASTIAN RADIATOR. 222. LAMP RADIATOR. 223. HOT-PLATE. 224. TRICITY ELECTRIC OVEN.

Electric Kettles. The next development lies in the direction of internally heated cooking utensils, where each apparatus forms a self-contained unit. Such apparatus is very efficient, but owing to its construction very expensive. The kettle is the usual form, but electric saucepans, coffee-makers, and numbers of similar utensils are also made. The heating element, consisting of wire wound on mica formers, is placed under the bottom of the utensil, carefully insulated from it, and suitably protected. The convenience and portability of such apparatus is apparent, and it is only their high prime cost which stands in the way of their extended use.

Electric Cooking. Electric cooking is destined in a very short time to supersede to a very large extent other systems of cooking—at least, in cities. During the past two or three years great advances have been made in the manufacture of thoroughly reliable cookers. A rapidly increasing number of private houses, hotels, and public institutions are now entirely dependent upon electrical methods of cooking.

In nearly all modern apparatus "nichrome"—an alloy of nickel, chromium, and other metals—is used. This wire has a very high electrical resistance and a comparatively low coefficient of expansion with the temperature at which the surface of the hot-plate is maintained. Up to the present the difficulty has been with the mica insulation, which tends to disintegrate at very high temperatures, but some of the latest types of hot-plates have

dispensed with mica altogether, and are consequently able to maintain the plate surface at a continuous red heat.

Electric Ovens. Modern electric ovens may be divided into two classes. In one, typified by the "Tricity" oven [**224**], the oven consists of a bright tinplate receptacle placed over an ordinary hot-plate, and having an opening at the top for placing over it another hot-plate, inverted. Owing to the bright surface of the oven, the heat-losses by stray radiation are small, and the cooking temperature (350°-400° F.) is maintained by the two hot-plates.

In the other class we have the "lagged oven," shown in **219**. This type of cooker somewhat resembles the gas cooker. The heating element is placed at the side of the oven, while stray heat-losses are minimised by liberal use of laggings, or protective coverings of heat-insulating materials. The heating inch of plate surface; and with this plate it is best to use special utensils having flat copper bottoms. The efficiency of this type of apparatus depends upon the filling space, about one and a half or two inches wide, between the oven and its outside casting with asbestos or silica-wool, or some other suitable insulator. Both the types mentioned have their advocates, but for constant work the heat-lagged type seems to be making most headway. Fig. **219** shows an electric cooker for a small house, and **225** shows a large kitchen. For grilling and toasting the heating element is exposed, and the perfect control possible renders not only grilling but all other cooking operations an easy, clean, and not disagreeable task.

Advantages of Electric Cooking. In addition to the cleanliness of electric cooking, and the fact that the cooking temperature is under perfect control, it has been proved time

225. THE INTERIOR OF AN ELECTRIC KITCHEN

element will withstand very high temperatures for long periods without disintegrating, its melting-point being about 2800° F. In its latest form it will withstand a working temperature of 2000° F. This metal is usually made up in ribbon form, which is wound on mica strips, and insulated from the metal of the hot-plates and heating utensils by further strips of mica. Hot-plates [**223**] made up in this way may be safely loaded up to 25 watts per square inch of hot-plate top surface. This gives a temperature on the hot-plate of about 600° to 650° F., and enables cooking operations with ordinary utensils having flat-bottom surfaces to be satisfactorily carried on in a reasonable time.

A very popular type of cooker—namely, the "Tricity"—uses as a standard a hot-plate 7 inches in diameter, requiring 800 watts. This implies a loading of about 20 watts per square and time again that there is a saving of about 12 per cent. in the reduced loss of weight in joints of meat cooked electrically. This is due to the fact that in the even hot temperature of an electric oven the surface of the joint is cooked immediately, and the meat juices are thus sealed in and retained in the joint, greatly improving its taste. The manager of a large electric restaurant, where 7000 persons are catered for weekly, calculates that the actual cash saving from this source represents to him £80 per annum, while his annual bill for electric energy is only £104.

Judging from the improvements which are being made in the design of electric cookers, and the low tariffs which are charged in many districts, electric cookers will soon be as familiar a sight as electric motors.

SILVANUS P. THOMPSON

Compass of the Instrument. Tuning. Correct Attitude of the Player. Open Notes and Positions. Bowing. Exercises.

THE VIOLONCELLO

The violoncello, or the 'cello, as it is commonly called, has four strings. As the character of their tone depends not alone on the tension, length and substance, but thickness, the strings are of different gauges. The material in ancient lutes may have been furnished from the intestines of cats, but the substance nowadays preferred is derived from young lambs, although goats, antelopes, and deer are laid under contribution. Increasing weight and depth of tone are gained by the two lower 'cello strings being covered with copper or silver wire.

Compass. The names of most of the parts of the violoncello are similar to those of the violin [page 1954]. If the viola extends the compass of the violin a fifth downwards, the 'cello continues that of the viola an octave further. The four strings are tuned in fifths. That on the left of the player is A (fifth line, bass clef). The next is D (third line), the third is G (first line), and the lowest is C (second ledger line below staff). Thus, the pitch of the top string is an octave below that of an A tuning fork.

Tune the strings in succession from the A, each a fifth lower than its neighbour. Correct their pitch at first by the notes of a piano, or by a set of pitch pipes. When properly tuned, these four strings give the "open" sounds of the instrument. In music they are indicated by a zero above each note.

Attitude of the Player. Sit on the fore part of a chair. Advance the left foot, which should be turned outwards. Draw in the right foot. Rest the left edge of the instrument against the calf of the left leg. Steady the right edge by the calf of the right leg. Grasp the 'cello firmly, so that the bow, when crossing the strings, may not touch the left knee. The instrument should be held securely in this way, so that the left fingers may be free to stop the notes firmly, and the entire hand change its position without having to support a heavy weight.

The Tail Peg. To ensure that the 'cello does not slip whilst being played upon, it is customary nowadays, especially with ladies who cannot hold the instrument in the way described, to use a steel or wooden stem, protruding 7 in. or 8 in. from the tail-end. This dispenses with the pressure of the legs, and leaves the body of the 'cello free to vibrate. The stem should be adjusted to such a height that the bow will not touch the left knee nor the right thigh when the first or the fourth string is sounded.

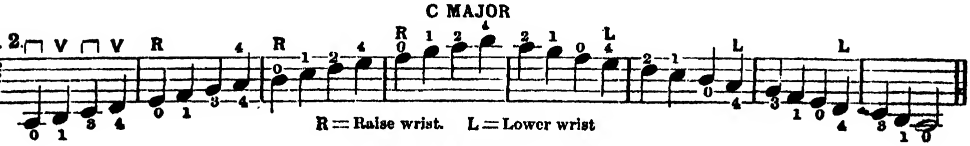
When in position, the scroll, or head of the 'cello should slant over the left shoulder. Place the thumb on the centre of the back of the neck of the instrument. Put the tip of the first finger on the first string on the fingerboard above and opposite to the thumb. Press down the tips of the second, third, and fourth fingers. Round the joints well on the third string; do not let them sink in. If the finger tips are not employed, the hand will not be properly rounded. Continue this exercise by putting the first finger and others in succession on the second string. Transfer them in the same way to the third and fourth strings. Make each movement emphatically.

Having well resined the hair, take up the bow with the right hand by the nut, or screw end. Hold the stick between the thumb and second finger. Let the inside of the hair touch the first joint of the middle of the first finger. The third and fourth fingers are used to balance the bow, and the first finger to give the necessary pressure on the strings. All movements with the bow must be done with a graceful wrist. The motions of raising, lowering, and turning the

WHOLE BOW—EIGHT BEATS FOR EACH STROKE

Ex. 1.


C MAJOR

Ex. 2.


A MINOR

Ex. 3.


THREE-STRING ARPEGGIOS

Ex. 4.

Ex. 5.

right wrist should be carefully practised—anything stiff or inflexible looks bad. Pains should be taken at first to keep the bow uniformly about an inch above the bridge at right angles to the instrument.

Exercise on Open Notes. Place the nut of the bow on the first string. Move the hair parallel with the bridge. Count eight slowly till the bow arrives at the tip. Meanwhile, the nut should not have been raised towards the fingerboard nor permitted to slant downwards. Keep the right elbow free, and the upper part of the arm close to the body, but do not move the shoulder. Return in the same way with the "up" bow, without lifting the bow off the string. Make the hair bite equally the whole length. Bow the other three open notes clearly in the same way, using the whole length of the hair. A down-bow, it will be understood, is from left to right, the up-bow being from right to left. The former is denoted in music thus, ⊓, or Λ, and the latter by ⊔ or V. When a change occurs from one string to another, it should be made cleanly by the motion of the wrist. Curve the latter outwards when playing on the first string, and inwards on the fourth string [Ex. 1].

C Major. Now essay the scale of C major [Ex. 2]. Begin with the down-bow on the open note of the fourth string. Depress the first finger of the left hand firmly. Get with an up-bow the note D, a whole tone above the C. Next, put down the third finger and stop E, another whole tone, playing with the down-bow. The F being at the distance of only a half-tone, does not require the same stretch. For this, put down the fourth finger and use the up-bow. Go to the third string. With the wrist raised, play the open note G. The first finger will give the A above and the third finger the B. C, only a semitone higher, will be stopped with the fourth. The motions of the bow, wrist, and fingers should be simultaneous. Continuing on the second string, play the open note D. Use the first finger for E. As the next note is but half a tone away, put down the second finger for F. Stop the G with the fourth. Without break, sound the open note A of the first string. Make the B above it with the first finger, the C with the second, and the D above with the fourth. When

G MAJOR STACCATO

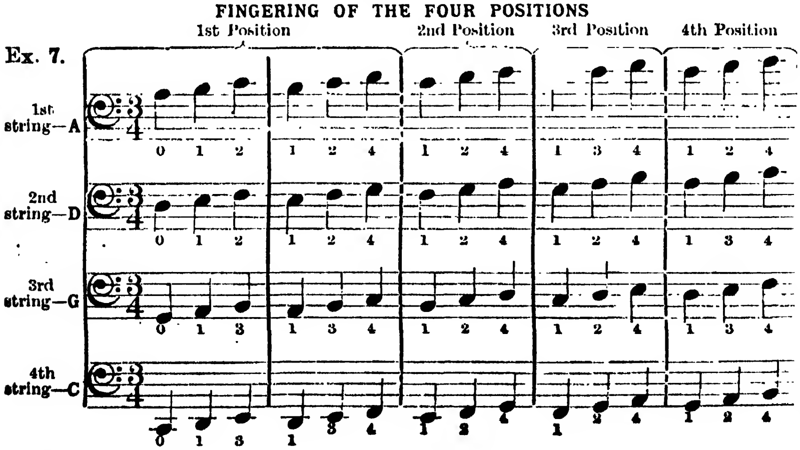
Ex. 6.

passing from one string to another, avoid unnecessary finger motions. If not carefully checked, fussy movements develop into affectations.

The First Position. Now go back with the same fingering. Do not continually raise the bow for successive notes. Balance it firmly. When the strings are changed, the sound should continue, whether the bow is at its tip, nut, or any other part. Throughout this scale, the hand is situated in what is known as the *first position*. Ex. 3 gives the fingering in one octave of the relative minor scale A. By this it will be seen that although the F and G are sharpened when ascending, the same digits are used.

FINGERING OF THE FOUR POSITIONS

Ex. 7.



If reference is made to the course on Theory or the Violin, the student will understand how the fingers which stop the notes, when playing the major and their relative minor scales, must allow certain half-tones to alternate with the series of whole tones. The stretch of the finger at definite points in each scale, therefore, is less than during the remainder of the progression.

FIFTH POSITION

Ex. 8.

1st string

Finger Stretching. Ability to extend correctly the left-hand fingers is an essential in 'cello playing. While the first and second fingers open freely from each other, it will be found difficult at first, owing to the muscles and shape of the hand, to extend the third finger beyond the distance of a semitone from the second. To overcome this awkwardness, 'cello students sometimes add to their stretch by placing corks between the second and third and third and fourth fingers. Try small corks at first, and avoid straining the fingers in any way. As the opening between the digits gradually widens, the span can be still further increased by inserting larger corks.

Arpeggios. Take the major and minor scales already given, and delete certain of the notes. [See Ex. 4.]

After practising the arpeggios over three strings, extend them over the four, as in Ex. 5.

Wherever the second and third fingers are used, or the third and fourth, give special attention to them. It is only by practice that the beginner can hope to make the weaker digits as serviceable as their stronger brethren. Equality of strength and independence should be the constant aim in view.

Bowing. To add to the suppleness of the right wrist, practise each exercise, whether scales or arpeggios, by bowing every note first with a separate stroke. When ability to do this evenly has been acquired, the same exercise can be varied by linking together two notes with one bow. Then, with one bow, play three notes, three and two, two and three, eight notes, two with one bow and the two following with two short bows, a group of four notes with one stroke, and the succeeding four with four short strokes. Further variation can be obtained by tying a succession of notes together smoothly with one long stroke. Then, make a similar number of notes staccato, either with one bow, or with the point and heel of the bow alternately.

Staccato. Staccato bowing is done usually with an up-bow near the tip. It is executed with a rigid arm. Each sound must be articulated by a special pressure whilst the wrist remains supple [Ex. 6].

Such exercises should not be done promiscuously, but systematically. The middle, the whole length, and the extremes of the bow should all be studied with the greatest care.

The thoughtful student who compiles his own exercises methodically, so as to strengthen and accelerate his execution, will make more progress than the pupil who ignores the study of theory and plays in a casual manner many published studies without perceiving their object. The object in view can never be attained without a careful perception of the motive aimed at. Amateurs frequently fail to advance in 'cello playing as they should do because they will not take the instrument seriously. Those difficulties which must be overcome if progress is to be made need first to be comprehended. This calls for mental as well as physical exertion.

Steady Repetition. It is by thoughtful rather than by merely mechanical practice that the hands can be properly trained, so that they do ultimately what is required, as if automatically. It is of little use to practise strenuously several hours one day in a week and neglect opportunities for study every other day. Far better concentrate the attention regularly on the instrument for half an hour every day, and draw up a system of profitable study.

Positions. Having become familiar with the fingering of the *first* position, the student should leave the open strings and proceed to the fingering of the *second*, *third*, and *fourth positions*. "In each position," says Duport, "the hand must preserve the same form as it took in the first, and the fingers must likewise maintain their respective distance, except their insensible and necessary approachment to each other in moving towards the bridge, owing to the stops becoming gradually closer." The fingering of the notes in the four positions is demonstrated in Ex. 7.

Those studies which the student may have already devised for the first position can be used for the higher shifts if transposed [see TRANSPOSITION]. These exercises will suggest fresh studies. When the technical gymnastics of any instrument have been mastered, the playing of melodies and other pieces will be found comparatively simple. In shifting from one position to another, the thumb must follow the hand lightly, touching the neck.

Tenor Clef. Hitherto, in the four positions, the bass clef has been employed. If that system of notation is continued for the higher shifts, the number of ledger lines above the staff becomes confusing. When, therefore, the fifth position is reached, the tenor, or C clef (C on the fourth line) is used [Ex. 8].

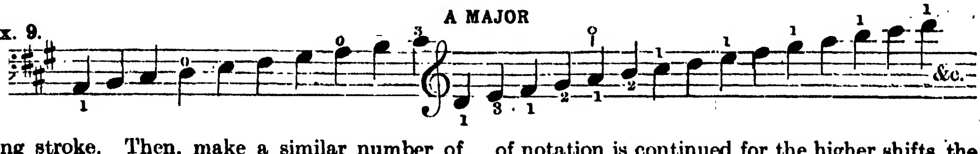
Beyond the A (first space above first ledger line) for extreme passages, it is customary to employ the G, or treble clef [Ex. 9].

In certain old scores the treble clef was sometimes written in 'cello parts an octave higher than the actual sounds, a system unnecessarily perplexing.

Thumb Positions. To make use of the extensive compass of the violoncello, the thumb, instead of being kept at the back of the neck, is

Ex. 9.

A MAJOR



Ex. 10. THE SHAKE — Preceded by an APPOGGIATURA

brought round to the front of the fingerboard. During the last note, before employing the thumb, its place is changed from behind the neck. It is held above the string at a tone's interval from the first finger. It then slides into its place horizontally upon the strings, and parallel to the bridge, so that two strings are touched at once. The middle of the thumb nail is over the lower string, and the first joint of the thumb over the higher string. Rest the left arm lightly on the side of the 'cello. Having thus made a position barrée [see GUITAR], stop the notes above with the first, second, third, and fourth fingers. The sign denoting the use of the thumb is printed thus ♀. When "same position" occurs after this sign, it means that the thumb must remain in the same place.

Orchestral Playing. If the student, presumably, is qualifying himself to take part in an orchestra, the thumb positions, the playing of harmonics, and those subtleties of expression in bowing cultivated by the soloist need not occupy the attention of the learner so much as the two lowest octaves of his instrument. These have the richest tone and most telling qualities, whereas in orchestral work the two highest octaves of the 'cello are seldom wanted.

Ex. 11. SPRINGING BOW

Solo Playing. Although the solo 'cellist who is really great is rare compared with the violinist, the ambitious student will not rest contented until he has familiarised himself with exceptional fingerings and bowings.

The Shakes. The shake, chain shakes, and passing shake must all be done with an even finger-motion, and practised till the movements are extremely rapid, although the bowing is done slowly [Ex. 10].

For the "springing bow," the lower middle part is usually employed. The arm and wrist must be free and lissom. Give a little extra vehemence to the first note of a group [Ex. 11].

The Vocal Quality. Nevertheless, it is well to remember that the greatest charm of the 'cello, when well played, consists in its power of gliding from one note to another, and of its peculiar vocal quality when dwelling on a note, closely imitative of the human voice. This sympathetic effect is heard to the best advantage in the lowest register of the instrument in slow passages, and it is that part of its compass which, in the orchestra, is of greatest value.

MOZART AND HIS FAMILY

The Art of the Designer. Its Relation to Fashion. Forms of Weaving and Methods of Calculation.

DESIGN AND DESIGNERS

A PLAN is as necessary in making a cloth as in building a house; and although the schemes that are drafted for cloth-making are called designs, they are in reality working plans. The man who prepares the designs is called the designer, whether his work is that of inserting dots upon squared paper or of turning out ornamental sketches. The former class is spoken of as technical as opposed to artistic designing, and it is with the purely technical side that we have to deal.

The name sounds a little forbidding, and the duties may seem mechanical, but it is exceedingly easy to underrate the demands that may be made upon the patience, discernment, taste, and skill of the technical designer. The higher branches of the craft call for an ability upon the part of the designer and colourist not inferior to that made upon the worker in freehand, and the highest classes of technical designing are at least equally well rewarded.

Requirements of Design. A woven fabric consists of two sets of threads intercrossed according to some determined order, and the order is arranged with more than one object in view. Appearance, or the forming of a pattern, is one great consideration, and usually the chief one, but regard has to be paid also to the stability of the structure. In the interests of wear the fabric must have a sufficiency of strength in both directions. The threads must be well bound together if they are not to fray, and to be ideally satisfactory the fabric must be well balanced with warp threads proportionate to the weft. The art of designing does not lie wholly in the placing of the threads; it embraces some liberty in the choice of the materials and in adjusting everything to the purpose in view, and especially to the price that can be paid.

Nobody can design cloth to any purpose without a shrewd idea of what will sell and of what the market is likely to want next, and these considerations have no necessary connection with what is ideally desirable or meritorious. So much misconception is entertained as to the functions of the technical designer that it is needful to emphasise the fact that he has to exercise his ingenuity within narrow limits imposed on him by the market and the capacity of the machines.

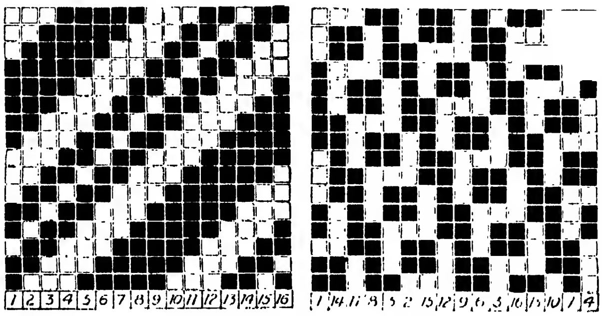
The degree of skill called for varies with the intricacies of the work, little or none being wanted for the making of plain weaves for uncoloured cloths, and very great skill to stamp new variations upon old themes with the impress of originality and timeliness. The production, for example, of the highest grade of worsted fancy trousering is of vastly more intricacy than might be supposed from a casual glance, and may involve the use of half a dozen different shades of grey to arrive at exactly the right cast of colour, and of contrast threads placed in exactly the right position to make an effective foil. In these goods the supreme desideratum is usually an irreproachable neatness and quietness of effect, but in designing tweeds more dash and loudness are required, which are obtained by the use of more violent contrasts. In either event a very narrow line separates right from wrong; and this trained artistic sense of what will please is of much greater practical consequence than any mechanical or scientific considerations. It may be said that the finished result in designing of this class is never hit off in one effort, but is arrived at as the result of the gradual refinement and improvement of the initial idea.

The Fashions. Fashion is the great idol that the designer has to consult; and although fashion is always changing and moving in cycles, it never exactly repeats itself. Plains are succeeded by stripes, and stripes by checks, in an apparently endless variety of widths and colours. Although his own old pattern-books are one of the richest sources of inspiration that a designer of fancy cloths can find, the new goods must always show some appreciable difference from those that sold when stripes or checks of a similar sort were in vogue before. The designer has to be well posted in respect of what others are doing, and most designers of technical fancy goods are supplied every season with books of patterns furnished by firms conducting a kind of subscription pattern library. Styles are found executed in silk and satin [2], or in light dress stuff, that, with adaptation, can be converted into effective designs in heavier materials.

Designs on Paper. The designer gives to the weaver a plan or design plotted out upon *point* paper [3], ruled in squares and divided by heavier lines into squares of eight. A black mark inserted in one of the small squares signifies that at this place the weft thread is to appear upon the surface, the warp thread passing underneath. It is barely necessary to indicate on paper the simple one-up, one-down alternation used in weaving a plain cloth, but such a design has the appearance shown in **4**. It is almost as superfluous to plot out the design for a simple three and one twill [**5**], where, in every pick or shot of weft, the weft thread passes over one warp thread and under three. The designs **1**, **4**, and **5** are for the guidance of the twister who threads the warp through the healds of the loom, for the overlooker, tuner, or tackler who places the gears into the loom, and for the weaver who has to see that the cloth is woven without avoidable defect.

Pegging Plans. The necessity for paper plans increases with the complexity of the structure. Apart from the plan showing the order of the threads as they occur in the fabric, a draft is got out for the guidance of the healders to show to which shaft of healds each thread in the repeat of the pattern belongs. Another draft or pegging plan is prepared for the overlooker to show how the pegs should be inserted in the cards of the dobby to control the order in which the shafts of healds are to be lifted. The object is to weave as few shafts as possible, and in order to reduce the number the lifts are carefully numbered and noted down in dots. When more than one order is possible, the designer is expected to choose that which will give the least trouble in the weaving.

Controlling Factors. There are many ways in which the effect can be altered, apart from the placing of the threads. The respective thickness of the warp and weft threads is one controlling factor. A weft much heavier than the warp gives a ribbed or corded effect running in the weft direction, and a disproportionately thick warp produces a rib in the warp direction. Then the order can be arranged so that even in a simple fabric one set of threads may predominate upon the face, and by the use of suitable materials one set may be entirely concealed. Again, fancy effects are obtainable by altering the tension upon alternating warp threads by using two or more warp beams. Similarly, by varying the spacing of threads by means of the warp *dents*, a fabric can be made with certain of its threads crammed together and with more or less open spaces between.



1. DESIGNS FOR TWILLS

Fancy Weaves. The simplest effects in fancy weaving are got by simple extensions of the elementary weaves. Thus, if, instead of weaving one-up and one-down, the design is altered to two-up and two-down, we get the familiar *hopsack* or basket weave. The ordinary twill is converted into herring-bone by twilling for a certain distance in one direction and twilling in the reverse direction for an equal distance. The changes necessary in operation are rung upon a number of elementary structures, of which the following are the principal:

(a) The plain weave. (b) The warp rib. (c) The weft rib. (d) The common twill. (e) The sateen or broken twill.

Each of these structures is susceptible of modification by itself, and the weaves can be combined either for the sake of effect or to secure firmness of texture, and the sateens, in particular, are often worked out on a large number of shafts.

Double Cloths. As well as simple fabrics there are also the so-called double cloths, of which the most complete example is the *reversible*, sold for mantles, overcoatings, and travelling-rugs, with a face of one colour and a back of another. The reversible is composed of two separate and independent fabrics, which are woven simultaneously one above the other, each having its own warp and own weft. A third warp, usually of cotton, is interposed between them; and this *stitching* warp, as it is called, is interlaced at intervals both with the upper and the lower fabric, so that the two are bound together as one. There are also double cloths non-reversible, in which there are two warps, one forming the face, the other forming the back, and united by a common weft binding both together. *Backed* cloths is a preferable name for these, and they are made often for the purpose of gaining weight economically. A finer and costlier warp is used for the face than for the back, and the woven appearance of the back is quite unlike that of the front. Backed cloths are in common use for worsted trouserings, and both backed and stitched double cloths are extensively woven in making cotton quilts.

2. SATIN CLOTH MAGNIFIED

Extra Warp. All weaving involves a certain amount of *take up* or contraction of warp-length, due to the greater or less bending of one thread around another. In weaving backed cloths it is usual to allow for a greater take-up in the face warp than in the back. In weaving together yarns of different kinds into simple fabrics, allowance has to be made for the varying degrees of elasticity; and thus in weaving a few threads of silk to form stripes in worsted, the silk is often warped upon a separate beam under different tension. In one sense this silk is therefore an *extra* warp, but it is not exactly in this sense that the words *extra warp* are to be understood in relation to the forming of fancy figures upon the face of light goods. In lappet woven muslins the extra warp threads are stretched above the ground warp, and the loom is fitted with needle bars governed by a wheel-plate. These extra threads are, at the right place and time, brought down to the level of the ground-warp, and are accordingly woven to the fabric at that place for the purpose of forming a pattern [7].

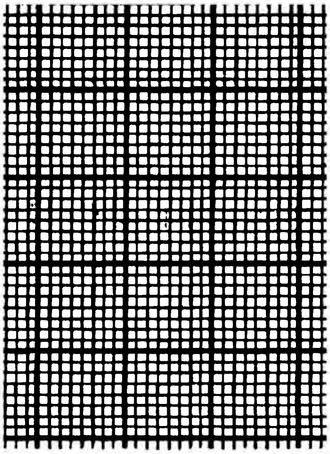
By using a special arrangement of auxiliary shuttles known as *swivels*, a figure can be formed with extra weft. The shuttles used to weave the ground weft cross from side to side of the cloth, but the swivel shuttle works only across its own pattern, and one swivel is provided for each pattern in the width of the piece. The apparatus has been discarded by most manufacturers, but the method is always a possible one of producing spiral and other patterns which are not obtainable by other means [6].

Gauze Weaving. A variation upon plain weaving that is used mainly in the silk and fancy cotton trades is the gauze structure. Gauze is not

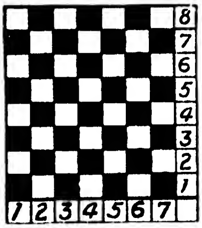
simply an uncommonly light fabric; it is one in which alternate warp threads are drawn aside from the straight course that they occupy in ordinary weaving. The loom is fitted with one or more sets of *doup* heddles or healds, whereby the alternates in the warp are pulled sideways and across their their neighbours. While in this position the weft is shot between them, and in a plain gauze the threads follow the pattern shown [8]. It will be seen that the insertion of the weft prevents the warp threads from uncrossing, as they would otherwise do, and thus maintains the interstice between the threads that would otherwise be filled. This expedient of crossing parallel warp threads is resorted to in weaving fancy *leno* and other lace-like fabrics in which it is necessary to maintain an open space between one group of threads and another. The doup action serves, as a matter of fact, as a lock stitch.

Pile Fabrics. A pile is raised on some fabrics purely by the processes of finishing, as in the case of the imitation furs made with a concealed cotton warp and a heavier mohair weft. Fibre is scratched from the weft yarn until it forms a cover for the weave beneath. There are, however, goods woven with a surface of loops, and these may be uncut, as in the familiar Turkish towelling or Brussels carpet; or cut, as in velvets or corduroys. The loop pile may be formed either out of the warp or the weft, and when a long pile is wanted warp threads are used to form the loops. The loom used in warp pile weaving is the ordinary one, with an addition to permit of the insertion of wires, over which loops are formed by the pile-warp, while the bases of the loops are secured between the ground-warp and the weft. The wires are withdrawn and replaced in each new *shed* continuously during weaving, and the loops can be cut, if need be, by a knife-edge attached to the wire. The pile then exists in the form of cut-ends of twisted yarn, and the finishing processes are designed to untwist this yarn and to conceal the foundation under a dense and bushy mass of fibres such as are seen in velvet. In an alternative process of weaving plushes, two fabrics are woven face to face; and when the warp loops joining them together are cut, two pieces of cut pile are obtained.

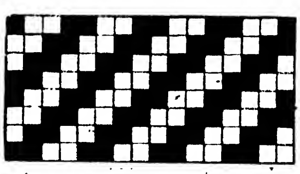
Weft-pile goods are woven in ordinary looms with one warp and two wefts—one weft to form the ground and to bind fast the secondary weft. The latter passes under one and over three, six, or nine threads, and these *floats* or loops require to be cut and the yarn to be burst into its constituent fibres. Velveteens are made with a weft pile, as are corduroys, and in the latter the loops are woven in lines with spaces between to form the valleys between the ribs which appear on the finished surface.



3. TEXTILE DESIGN PAPER



4. DIAGRAM OF PLAIN CLOTH



5. DESIGN FOR TWILL CLOTH

Helps in Designing. Designers are attached ordinarily to one branch of the industry, making a more or less restricted range of goods upon fewer varieties of looms than have been enumerated here. The problems of different designers are not the same, but there are similarities in the aptitudes required from them. Designers are expected to be quick judges of material, and to be able to tell the quality of a given cloth from a very small sample. They should be able to estimate approximately the count of yarns from its look, and know how to arrive at a given result by the shortest means. Their work calls for a good deal of incidental calculation, the labour of which can be considerably shortened by the use of ready-reckoning tables and charts. Diagrams are published from which one can see at a glance the equivalent counts of yarns that are numbered according to the several systems in vogue. Instruments are procurable for facilitating the weighing and measuring of threads withdrawn from cloths that come for matching and for the ready counting of threads as they lie in the fabric. It has at the same time to be said that some of the ablest men dispense quite successfully with these, and continue to work with the very simplest accessories.

Making Calculations. The simple calculations that fall into the designers' way include reckonings as to the total weight of one piece containing a known number of threads of known count. The weight of a warp is readily found by multiplying together:

Ends per inch × width of cloth in inches × yards of warp, and dividing the product by the yards per hank × yarn count.

In practice some allowance has to be made for loss of weight in weaving, and this amount varies with the material, and is determined by experience. In weaving cotton it is customary to add $1\frac{1}{2}$ per cent. for waste.

The weight of the weft is ascertained by multiplying:

Picks per inch × width of cloth in inches × warp length, *minus* allowance for take-up in weaving, and dividing by the yards per hank × yarn count.

A larger allowance, variable in amount, has to be made for waste of weft in weaving, and in the cotton trade it is customary to allow 4 per cent.

The weight and price of the materials being known, we are well on towards estimating the total cost, which is arrived at by adding the expenses of warp and beaming, weaving, and mending, and an allowance about equal to the weaving wage to cover the miscellaneous charges of the establishment. In addition, there are always certain expenses in connection with selling, and there may be costs of dyeing and finishing.

Incidental Calculations. There are many incidental calculations, some of which require to be made afresh on every occasion, and others that are covered by formulæ or that can be settled on the basis of past experience. There is, for instance, the question—which is important in goods liable to shrinkage in finishing—of how a cloth should be *set* in the look in order to contain the right number of threads per inch in the long run. Ratios have been worked out for each of the standard weaves, and there are formulæ for arriving at the allowance to be made for various counts of yarn, so that, knowing what proved correct in one instance, the designer can calculate the amount needed in another.

When it is desired to calculate the number of threads which can be laid side by side in one inch it is first requisite to estimate the diameter of the yarn, and this is customarily done according to Ashenhurst's rule that the

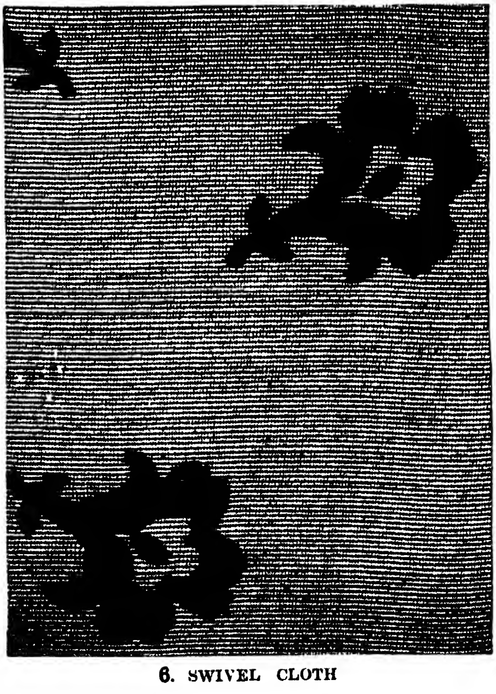
$$\text{Diameter} = \frac{1}{K \times \sqrt{\text{yards per lb.}}}$$

Under this formula K is given different values according to the material of which the yarn is made. Approximations which have gained acceptation give

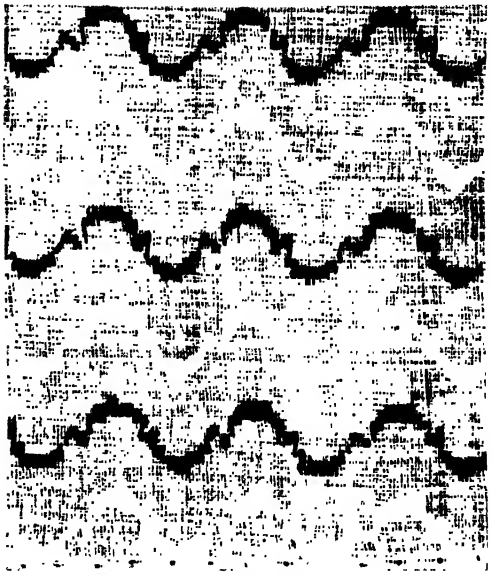
k a value of ·84 for woollen yarn.
,, ,, ·86 ,, crossbred worsted yarn.
,, ,, ·90 ,, botany.
,, ,, ·92 ,, cotton and linen.

In view of the differences in specific gravity between raw materials of different origins, and the large variety of twist given in spinning, the calculation can be approximate only.

Becoming a Designer. The recognised way of becoming a technical designer is to effect an arrangement with a designer employed by a large firm, and to learn the business under his tuition. The designer in a large mill making fancy cloths has a good deal of clerical work to do in writing out instructions upon tickets, and this work, demanding patience and accuracy, is one of the first tasks to



6. SWIVEL CLOTH

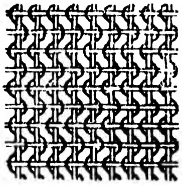


7. LAPPET CLOTH

which the learner needs to accustom himself. Every good designer can himself manage a loom, and in the woollen and worsted trade there are opportunities for the learner to practise hand loom weaving in the making of pattern lengths. A good, all-round knowledge of mill processes being needful, it is practically indispensable to the young designer to take a course of lessons in the excellent technical schools that are to be found in every considerable textile industrial district.

There are good positions to be obtained by men of experience and ability, and as much as £1000 has been paid to their head designer by firms in the first rank. At the other extreme are designers who cannot hope to be paid more than 35s. a week, or the wages of an overlooker.

Some designers are expected to add commercial functions to their office, and to act as salesmen, designing and selling their own cloths. In these cases the remuneration is determined as much by the salesmanship as by the technical capacity displayed. Some are introduced to the market every season by their employers, and others are confined rigidly to the mill and to mill hours.



8. DIAGRAM OF GAUZE

The Importance of the Designer. The responsibilities of designers vary as much as the range of salaries would suggest. The position is of prime importance in a mill owned by ambitious principals eager to reach the top in the production of fancy cloths, and a good designer will keep their mill going as surely as a bad one will shut it up. To makers of plain and simple cloths the choice of designers is less material, and in such cases the designer often occupies the place of deputy manager, and in due time passes out of the designers' room to take up the management of a weaving mill. The prospects of obtaining situations are not limited to this country.

J. A. HUNTER

GREAT ICE RIVERS FLOWING DOWN THE ALPS

47. A MEETING OF GLACIERS AT THE FOOT OF PIZ, BERNINA, SHOWING THE MORAINES

48. MOUNTAINS OF ICE ON THE PERS GLACIER

Erosive and Transplanting Action of Running Water. Deltas and Their Formation. Glaciers and Their Important Work. Moraines.

ACTION OF FLOWING WATER & ICE

We have already seen that a part of the rain which falls upon the surface of the earth sinks underground, and there performs important geological work. But a great deal of the water which is precipitated from the atmosphere does not sink into the ground, but remains on the surface, in the forms of brooks and rivers, which run into lakes or into the sea. This running water performs a very important work of erosion on the surface of the land; it has done much in the past, and is doing much in the present, to mould the contours of the landscape. In those few parts of the world where the surface is a dead level, the rain accumulates in pools, which ultimately either sink into the ground or evaporate into the sky. But in most places where rain falls the surface is not level, and the rain, obeying the law of gravitation, runs down the nearest slope.

If we watch the rain falling on a mudbank or on the seashore, we see that it traces little valleys in the soft ground, whose size and direction are conditioned by the slope of the surface and the nature of the soil. Stones or harder portions of the surface cause the running streams to divide or ramify into a network, and a miniature river system, with tributaries, watersheds, and affluents, is thus produced. It is precisely in such a fashion that the great river systems of the world have come into existence, and that valleys and gorges have been carved out of the hills or table-lands of the more primitive rocks.

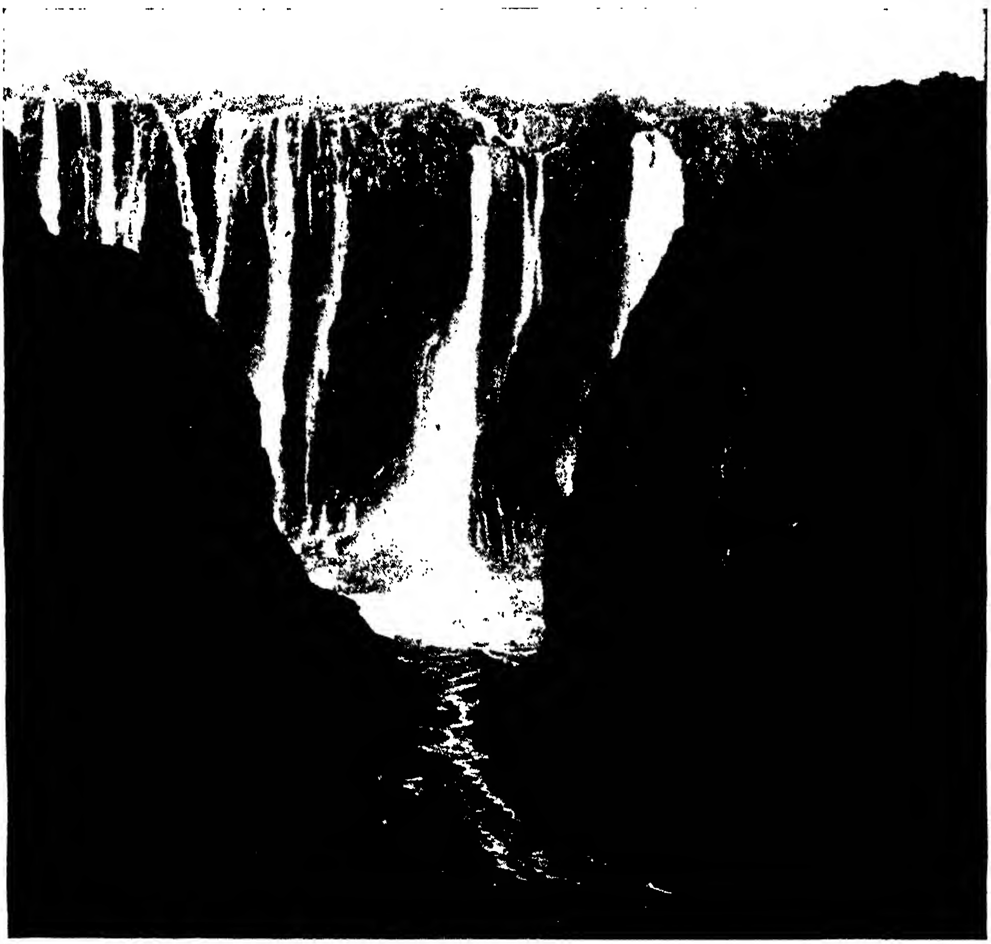
We can see on every hand examples of the way in which running water carves its course along the earth's surface. This it does in virtue partly of its own motion and partly of the sandy or gritty materials which it carries in suspension. When water flows along the surface of a soft and friable soil, it washes away the superficial portions, and carries them along in mechanical suspension with a force directly proportional to its speed and to the size of the grains which compose the soil. A rapidly flowing river or a torrent going down in spate is capable of transporting large pebbles, or even small boulders, which are usually dragged along the bottom of the watercourse, and thus act as a plough excavating the soil over which they pass. The speed and extent of the work of excavation depend also upon the nature of the ground. A river takes a long while to carve its way through solid granite, whereas it may rapidly wear a deep valley in soft, sandy, or muddy rocks.

There is a great deal of evidence to show that the valleys through which all large rivers run have been actually carved out by the rivers themselves. They vary immensely in size and character, according to the speed and volume of the river and the nature of the rock through which they have been worn. The gigantic gorge of the Colorado and the tiny trough of a Hampshire trout stream seem, at first sight, to have little in common, but they are the product of the same instrument.

The actual erosive power of running water is best illustrated by a waterfall or torrent. Everyone is familiar with some example of the gorges cut on a small or gigantic scale by running water on the hardest rocks.. One of the finest examples in the world is that of the Niagara River, which plunges in its world-famed falls over a mass of hard limestone, under which lie soft, shaly beds. These falls, at present, stand about seven miles above the mouth of the Niagara River, and there is abundant evidence to show that at one time this river fell over a cliff which formed the shore of Lake Ontario. The erosion of the water, aided by the stones which it carries down and the ice of winter, has gradually worn the cliff away for these seven miles, thus forming a deep ravine which will ultimately extend back to Lake Erie. The gorge of the Victoria Falls is another example of the same action. The great majority of waterfalls are thus placed at the head of gorges which have been cut by falling water, but there is no definite distinction between a waterfall, a cascade, a rapid, a torrent, and an ordinary river. Such difference as exists is due to the slope down which the river flows.

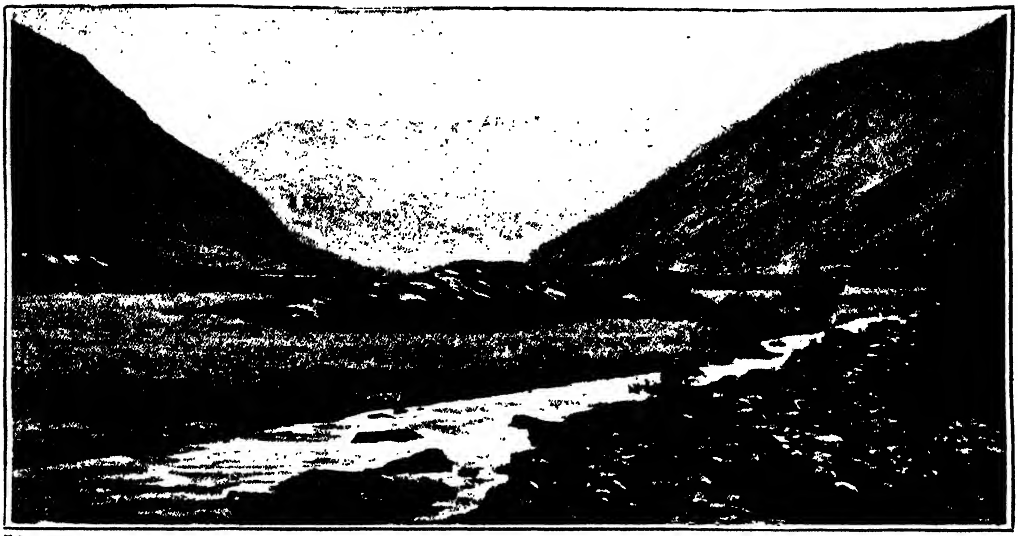
Pot-holes. A proof of the power of running water to abrade the rocks is afforded by the *pot-holes* [**58**], which are familiar objects in the bed of a rapid stream. These are large or small hemispherical basins which have been worked out by eddies whirling round stones and pebbles which drill out the rock. Very often, when the stream is low in summer, and these pot-holes are left empty, a heap of loose stones is found lying in them, ready again to take up the work of abrasion when the stream comes down in flood and the water whirls them round and round, to scour the pot-holes larger.

It is frequently by the gradual enlargement of such pot-holes, until they emerge into one another, that the river deepens its rocky gorge, just as a stealthy burglar cuts a panel out of a door by boring a series of closely adjoining holes with his centre-bit. But the tendency of the river is to wear down its course until its slope has become so gentle that it loses almost all its erosive power. It also tends to widen the valley through which it runs by altering its course from side to side. If it happens originally to run in a perfectly straight course—which is very unusual, but may take place where it has descended the line of some fault or fissure in the strata—it continues to run in that straight and narrow path, but it is much more common that it should form loops and bends, owing to the original inequalities of the slope and texture of the surface. When this is the case, a river always tends to widen its course and exaggerate its bed, because its current bears with greater strength on the concave side of each bend. This side of the bend is worn away, while the opposite side, where the water is comparatively still, is built up at the same time by the deposit of sediment. It is in this way that great river valleys like those of the Thames and Mississippi have been constructed, and that the present river flows down in a winding stream between wide banks of alluvial soil which the river has brought down from higher portions of its course.



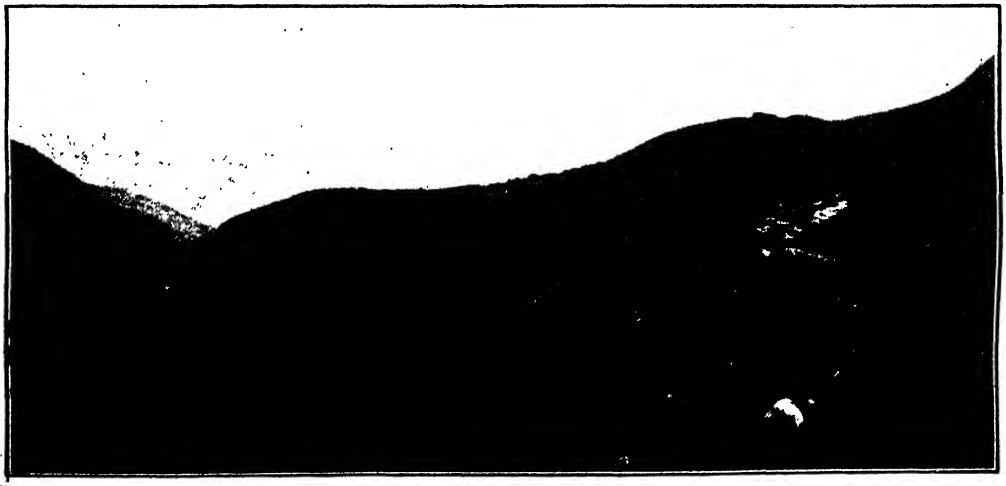
49. THE GORGE OF THE VICTORIA FALLS, ZAMBESI RIVER

Rivers Transport Sediment. Rivers, indeed, are not only *destructors* but *constructors*. In addition to their erosive action in carving out their valleys, they have also a constructive



50. THE BED OF AN ANCIENT GLACIER LAKE, SHOWING IN THE CENTRE THE ROUNDED AND STRIATED ROCKS—A VIEW LOOKING UP THE PASS OF THE VALE OF NANT FRANCON, NORTH WALES

51. A PERCHED ERRATIC BLOCK OF STONE THAT WAS FORMERLY CARRIED ALONG ON A GLACIER AND NOW STANDS ISOLATED FROM ITS STRATA AT CWM IDWAL, IN NORTH WALES

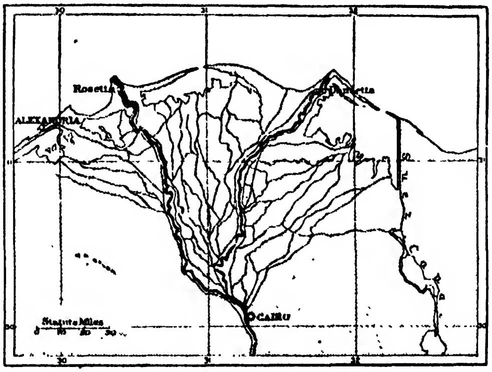


52. ROCHES MOUTONNEÉS OR GREY WETHERS—ROCKS AT CWM IDWAL, NORTH WALES, THAT HAVE BEEN SCRATCHED AND ROUNDED BY THE GLACIER THAT HAS PASSED OVER THEM.

The photograph of the Victoria Falls on page 2746 is supplied by the British South Africa Company.

action in depositing *alluvial soil,* which is especially important to us because it happens to be particularly well adapted to the growth of vegetation. The ability of a river to transport sediment depends entirely upon the speed at which it flows. High up its course among the mountains, where it flows with torrential rapidity, it tears away sand and earth and stones from its banks and bed and carries them along down to the plains. But when it reaches a place where the slope is gentle, and the water consequently flows more slowly, it is no longer able to transport the materials which it has carried thus far, and it begins to drop them along its bed. A river always flows faster at the middle than at the sides, because of the friction caused by its banks, and it thus tends to deposit materials which it can carry no further along its sides, especially on the convex side of every bend, where the current is directed away towards the opposite bank.

River Terraces. As the course of the river wanders from side to side of its valley, it leaves behind it broad flats or terraces of alluvial soil, which are at first overflowed periodically when more water comes down in the rainy season than the actual watercourse is able to hold, but which are ultimately left permanently dry when the watercourse has been sufficiently deepened. In this way we get the typical river valley, with the river flowing along its winding course in the middle of the broad alluvial terraces rising on very gentle slopes up to the foot of the hills which bound the valley on both sides, and by their height mark the depth to which the river has cut it from the surrounding country.



53. DELTA OF THE NILE

Deltas. The final end of a river is usually in a lake or sea. There are a few exceptions in countries where rivers end by being absorbed in sandy deserts. But the course of the river from the higher ground to the lower generally ends in some larger body of water. To this it transports such of the finer sediments as its gradually slackening stream is able to bring to the end of its journey. When the stream of the river enters the lake or sea it gradually slows down until it ultimately comes to rest, and, as it slows, it gradually drops its sediment to the bottom of the water. In this way vast deposits are produced by the larger rivers. It has been said with some truth that the whole of Lower Egypt is simply the accumulated sediment of the Nile, and that Holland has all been transported by the Rhine from the mountains of Switzerland.

Where a great river enters the sea it is constantly in the habit of building up new land, which is known as the *delta* [53], because its shape usually corresponds to the fourth letter of the Greek alphabet. The deltas of the Nile and Mississippi cover a great area of ground and project far out into the sea. They are constantly being added to by the great rivers which have built them.


54. CREVASSES IN THE PERS GLACIER

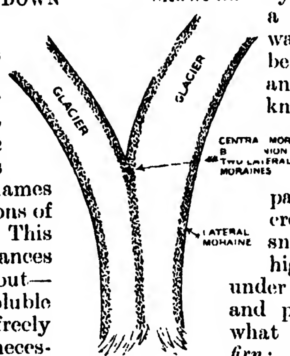
55. MORAINE CUT THROUGH BY BLOODY BRIDGE RIVER, NEAR NEWCASTLE, CO. DOWN

Why the Sea is Salt. Rivers not only carry sediment, which is *mechanically suspended* in their water in consequence of the speed at which they flow, but they also *dissolve* many substances, such as salt, various carbonates and sulphates. The Thames is estimated to bring half a million tons of mineral salts into the sea every year. This constant transport of dissolved substances into the sea has made it salt throughout—common salt being the most readily soluble of minerals, and therefore the most freely transported by rivers. It is thus a necessary consequence that all lakes without an outlet must eventually become salter and salter, since the amount of water in them is kept practically constant by evaporation, which does not affect mineral salts constantly poured into them. The Dead Sea, thus fed by the Jordan, and the Great Salt Lake of Utah, are well known examples. In this way, also, though much less appreciably than by mechanical transport, rivers are always at work removing solid matter from the land and wearing down its general level. In return, as we shall see directly, it is largely to this same work that we owe the building up of new continents.

Glaciers. A *glacier* is similarly a river of ice which performs the work of erosion on the land in much the same way as an ordinary river, though there are well-marked differences which enable the geologist to distinguish the work of a glacier from that of running water. Water assumes the solid form of ice at a temperature of 32° F. In the regions bordering the North and South Poles the normal temperature at sea-level stands below this throughout a great part of the year, and consequently the land is permanently covered with an ice-sheet.

In temperate climates like our own it is only in the depth of winter that the temperature remains below the freezing point long enough for the ground to be covered with ice or snow. But among the hills the case is different. The higher we rise above the sea-level the lower does the temperature fall, and there is a definite level known as the *snow-line*, above which water normally exists in the form of snow or ice. This snow-line varies in height according to the district, being on the actual sea-level at the Poles, and as much as 18,000 or 19,000 ft. above the sea in the tropics. In the Alps the snow-line stands at 8,500 ft., and there is no hill in the British Islands which quite rises to it, though Ben Nevis comes very near.

How Glaciers are Formed. In countries where the hills rise above the snow-line, water which falls from heaven—or, to put it more accurately, is condensed from the atmosphere—remains frozen throughout the year on the hills which are high enough. On the higher parts of such a mountain chain the *snow* is loose and soft, much as we find it on the ground after a winter snowfall. Lying as a rule upon a slope, it has a tendency to creep slowly downward by gravitation. If the slope be considerable, it often breaks loose and rushes down in huge masses, known as *avalanches*, which often cause great destruction, and have a marked erosive effect upon the rocks over which they pass. But when the snow only creeps slowly downward, and more snow is continually being deposited higher up, it slowly compacts itself under the pressure of the upper layers and passes first into the condition of what in Switzerland is called *névé*, or *firn*; later on its separate grains are squeezed together, and the whole mass passes into compact crystalline *ice*. It is in this way that glaciers, or ice-rivers, are formed. Like ordinary rivers, they



56. DIAGRAM OF GLACIER, SHOWING TYPICAL MORAINES

57. STRIATED BOULDER IN SITU, IN LOW CLIFF OF BOULDER CLAY, DIGANWY, CARNARVONSHIRE

seek the direction of greatest slope, gravitate thus to the gorges and valleys of the hills, and move steadily downward. We are accustomed to think of ice as a solid and rather brittle substance. But under the considerable pressure exerted by its own weight in great masses it is capable of flowing like water, although much more slowly and with far greater viscosity.

Glacier Motion. A glacier is continually in motion like a river, though its motion is so slow that it was only detected when science was called in to study Alpine phenomena [see page 293]. If a row of stakes be driven into the ice right across a glacier, in the course of a few days it will be found that the whole line has moved downwards in reference to fixed stakes on the rocky banks, and also that the line is no longer straight, but has developed a curve, which is convex downward. In other words, the ice in the centre of the glacier moves faster than that of the edges, just as happens with the water of a river; and in both cases it is the friction of the banks which accounts for this [**47**].

As a rule, the motion of the ice is slow, being about one or two feet a day in the Swiss glaciers, though in the glaciers of Greenland the rate of motion is sometimes as much as 50 or 100 ft. in the twenty-four hours. The ice adapts itself like a plastic fluid to the irregularities and curves of the bed in which it moves. In consequence of the bending which it undergoes in moving downwards along an ordinary valley it is constantly cracking into *crevasses*, which sometimes swallow up mountaineers. These crevasses keep reuniting and changing in position [**54**].

If the glacier comes to a precipice in its downward course it flows over in an *ice-fall*, which is all splinters and pinnacles, and corresponds to a waterfall in a river. The steady flow of ice is largely due to the phenomenon known as *regelation* [see PHYSICS], which consists in a constant momentary melting and refreezing of the ice, due to changes in pressure.

Glaciers Transport Rocks. As the glacier travels downward it does a great deal of geological work. It transports a large bulk of rocky fragments and detritus; it erodes the bed in which it travels; and ultimately it heaps up vast deposits of débris at its lower extremity. It will be obvious that the fragments of rock which frost and other agencies break off from the banks of the glacier bed fall upon the surface of the ice and share its motion downward toward the valley. They are naturally ranged along each side of the glacier, and there form two long beds of stones and fragments, which are known as *moraines* [**55**]. If two glaciers meet where their separate valleys converge, two of their *lateral* moraines coalesce, and are carried down the centre of the larger glacier thus formed; this is known as a *central* moraine [**56**].

When the glacier travels down the valley below the snow-line it reaches a spot at which its ice melts away in the warmer air, and the glacier there ceases or gives birth to a river. It is at this spot that all the rocky fragments which have been brought down by the glacier are heaped up in a vast accumulation which is known as the *terminal* moraine [**56**]. The moraines of ancient glaciers are very common objects throughout the whole of Northern Europe, showing that at one time a vast accumulation of ice covered the whole of this region.

Glacial Erosion. A glacier is also a powerful agent of erosion. The ice in its downward movement rasps and grinds along its bed, and acts as a plough. Further, a great many of the stones which fall upon the surface of the glacier tumble into crevasses, and sink down to the bottom, where they are frozen into the lower part of the ice and dragged along, scratching and eroding the surface of the ground beneath. Consequently, the bed of an ancient glacier [**50**] is characterised by rocks which are polished and rounded, and at the same time considerably scratched, or *striated* [**57**], the scratches all running in the direction—that in which the glacier formerly moved. They are caused by the fragments of rock which were frozen into the lower part of the glacier, and served as teeth to its powerful rasp. The underlying rocks are only superficially scratched, and present a generally rounded aspect, because all their edges and angles were planed off by the powerful pressure of the ice-sheet, often hundreds of feet in thickness. From their resemblance in contour to the backs of sheep, such rocks [**52**] are frequently known as *roches moutonnées*, or *grey wethers*.

58. POT-HOLE IN GLACIER GARDEN, LUCERNE

Sometimes huge boulders, which may contain many tons of rock, fall upon the surface of a glacier, and are transported by it to positions far removed from that of the parent rock, and the existence of such *wandering*, or *erratic, blocks* [**51**] is always the sure indication of the former existence of a glacier. Where the land has once been covered by a sheet of ice there is often left behind a characteristic deposit known as *till*, or *boulder clay*. This consists of a stiff clay, hardened from the fine mud which the glacier rubbed down under its enormous pressure, thickly filled with the larger or smaller rocky fragments or boulders. The whole of our islands was once covered by a vast sheet of ice, and traces of glacial action are found scattered widely over them.

W. E. GARRETT FISHER

The Materials and Tools for Patterns. Pattern Making. Moulding Tools and Practice. Bedding-in. Turning Over. Sweeping.

PATTERN MOULDING

WE are now in a position to consider first the methods of pattern construction, and then the broad systems of moulding adopted.

The Pattern. The pattern must be considered from two principal points of view—that of its method of construction and maintenance of form (matters which it has in common with wood-working generally), and that of its moulding, or facility for delivery from the sand. It is the last named which separates pattern-making as a trade from carpentry and joinery.

The Materials. It is obvious that maintenance of form may be secured in one of two ways, either by employing a non-perishable material, or by adopting those strong methods of construction which are practised in the wood-working trades generally. Both are employed in pattern-making. Articles of small and moderate dimensions, from which hundreds or thousands of moulds have to be taken, are made in metal, while others—namely, those of large dimensions, and those of any sizes from which comparatively few castings are required—are constructed in wood. These last include by far the largest number.

Timber. Then, as there are different kinds of timber, some stronger and more durable, some less given to warp and shrink than others, selection is made from several sorts to suit different classes of patterns. Yellow pine and mahogany are chiefly used. Other woods are occasionally employed, but not to any considerable extent. Yellow pine is suitable for large patterns, mahogany for those of small size. Both woods must, of course, be well seasoned, and the straighter the grain and sounder the stuff the better. The choice of yellow pine as the principal material for pattern-making might seem to be objectionable on account of its softness and openness of grain, as being ill-adapted to stand the rough usage of the foundry and to resist the action of the moisture in the foundry sand.

But in patterns properly constructed these objections have little reality in fact, for they are protected from excessively rough usage by the insertion of rapping and lifting plates, and the porous grain is protected with varnish or paint. And, on the other hand, these possible evils are much more than counterbalanced by the advantages of moderate price, straightness of grain, workability, and fair capacity for resistance to heat and moisture. And, further, many patterns are moulded from only once, or a few times, and for these pine is amply good enough. For patterns which are to have a very large number of mouldings, and of not excessive dimensions, there is always the harder but more costly mahogany available.

Tools. Being a wood-working trade, the tools used are nearly identical with those employed by carpenters, joiners and others. The principal ones will be found illustrated in the series devoted to Carpentry and Joinery, while underlying principles of their design are treated in the series on Tools, so that only a bare list of pattern-makers' tools need be offered here. They are the following:

SAWS. Hand, tenon, dovetail, bow, compass, and keyhole.

PLANES. Jack, trying, smoothing, rebates, and rounds.

CHISELS. Paring, 1½, 1¼, 1, ¾, ½, ¼ in.; firmer, 1½, 1, ¾, ½, ¼ in.

GOUGES. Paring, flat, 1½, 1, ¾ in.; middle-flat, 1¼, ¾ in.; quick, 1¼, 1, ¾, ½, ¼ in.; firmer, 1½, 1¼, 1, ¾, ½, ¼, ⅛ in., to which may be added a few bent gouges for core-box work.

TURNING TOOLS. Gouges, ¾, ⅜, ¼ in.; chisels, ¼, ⅜, ¼ in.; side tools, right and left handed, ¾, ½ in.; round noses, ¾, ½, ¼ in.

BORING TOOLS. Brace and set of bits, half-dozen gimlets, half-dozen bradawls.

MEASURING TOOLS. 2 ft. standard rule, 2 ft. iron contraction rule, 12 in. try-square, 4½ in. try-square, two set-squares, bevel, two pairs of trammels, large and small; wing compasses and spring dividers, two small marking gauges, and a panel gauge. Two pairs of callipers, one inside, one outside.

MISCELLANEOUS TOOLS. Hammers, light and heavy; wooden mallet, two screwdrivers (one large, one small), drawknife, axe, spokeshave, hone, two gouge slips. A somewhat smaller selection will suffice for a beginning. Many workmen will double the number. This is only a representative selection, and no more.

Machine Tools. The machine tools used in pattern shops embrace lathes, circular and band saws, planing machine, trimmers, and sometimes a special apparatus for the setting and sharpening of circular and band saws. So much of economical working necessarily depends on the employment of the machines that even in small shops employing only half-a-dozen hands these should find a place. There should be even in these two or three lathes, ranging in dimensions from 5 in. to 10 in. centres, one of which should properly be a face lathe, also a circular saw, either of the common type, or of the dimension kind, the latter being preferable where one saw-table only is used, a band-saw of light construction, with wheels

of not less than 2 ft. 6 in. diameter, the width of saws to range from ⅜ in. to 1 in., and one planing machine, being either a surfacing machine or a thicknessing machine, or both in combination. All these machines should be under the charge of one man, as increased efficiency is thereby obtained.

The Pattern: Its Permanence of Form. There are five principal methods by which permanence of form is secured in patterns, —open joints, boxing-up, halving, lagging up, and segmental construction, each one being adopted in different classes of work, and two or more often being combined in one piece. Their necessity is due to the treatment to which patterns are subject, of moisture in the sand, and of dryness out of the sand and in the stores.

Open Joints. These fill a valuable place in pattern work. The necessity for their use occurs in wide pieces. If, for instance, a piece of board be 6 in. or 8 in. wide it cannot shrink or expand much under changeful hygrometric conditions. But if, say, 18 in. wide, or if a broad pattern of 3 ft. or 4 ft. in width be glued up like a table-top, its width will be constantly changing, according as it is in or out of the sand. These changes are minimised by using narrow strips with joints open to the extent of $\frac{1}{16}$ in. or $\frac{1}{8}$ in., in which space the movements of the boards are localised. Fig. **53** shows a broad plating with open joints. The separate pieces are often dowelled, and they are retained flat by the other parts of the pattern on which they are fastened.

Boxing-up. This is preferable to making large patterns of solid timber, for three reasons—first, because shrinkage is lessened; secondly, because timber is economised; and thirdly, because the weight is reduced. Patterns are boxed up by nailing or screwing top and bottom sides to cross bars [**53** and **54**]. There is a right and a wrong way of doing this. The right way is to carry the sides up, as in **53** and **54**. The wrong way is to bring top and bottom right across, as in **55**. The reason for this difference is that when the top or bottom shrink or swell they cause overlaps, which tear the sand up.

In wide, boxed-up patterns, the top and bottom are made with open joints [**53**].

Halvings. Halvings [**56**] fill a large place in pattern work, as they do in carpentry. But they are employed more frequently in the former trade, being adopted in most cases where tenoned and mortised joints would be made by the carpenter and joiner. They are more easily cut, and are substantially as serviceable for patterns, besides which they have the very great advantage of permitting subsequent alterations in patterns, which fill a large economical place in the trade.

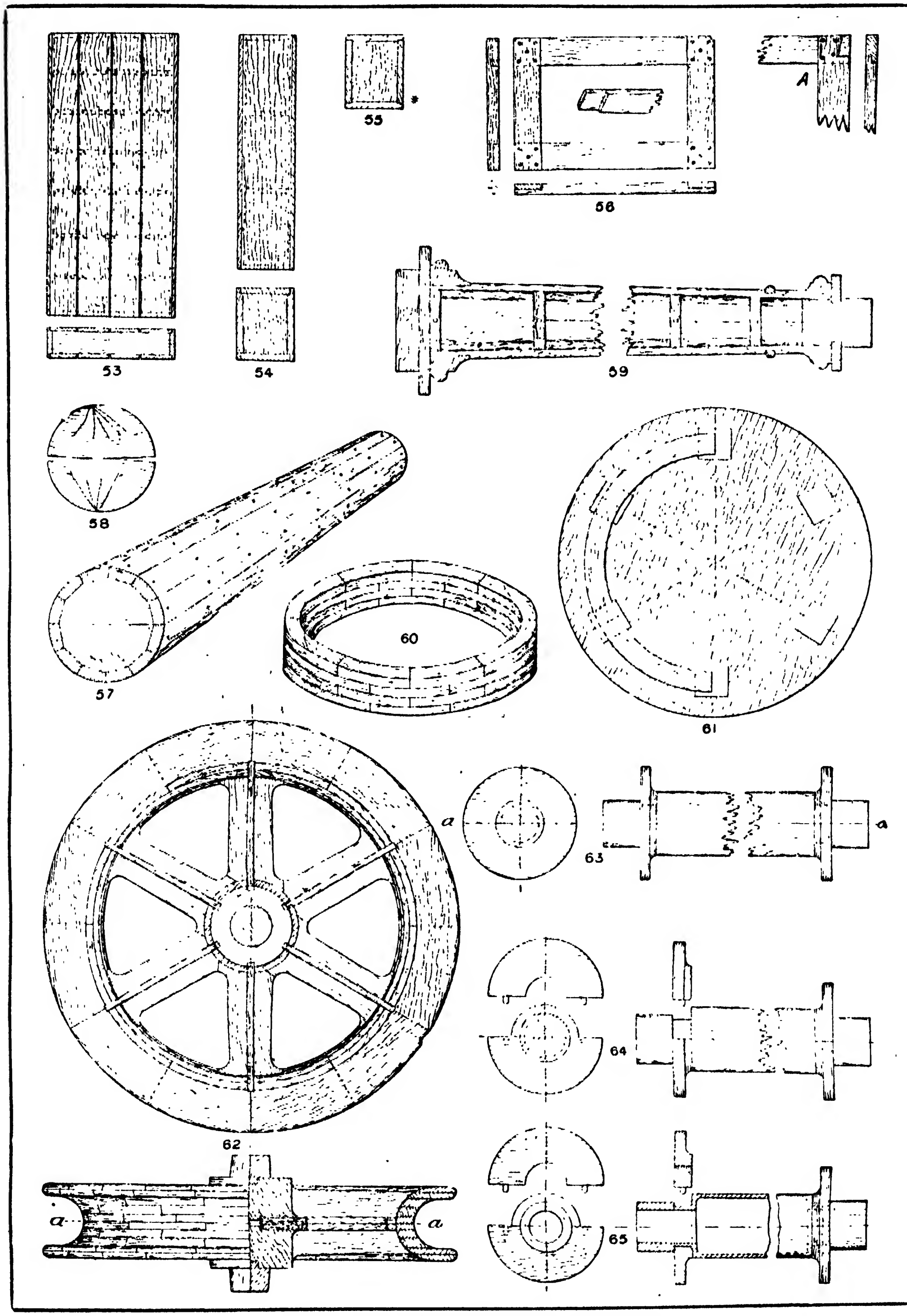
Halvings are adopted when framings have to be constructed for which the crude device of cutting out of solid board would involve short grain. A single example of a halved frame, typical of hundreds of variations in outline, is given in **56**. With the halving a dovetailed form is frequently combined (A) to prevent all risk of the joints opening.

Lagging-up. This is adopted in cylindrical pieces, as pipes, columns, and engine cylinders, when the diameter exceeds 4 in. or 5 in. The "lags" [**57**] are narrow strips laid round on cross bars and glued thereon, and also by their adjacent edges. The object is the same as in the preceding examples—namely, to localise and lessen the change of form. Solid stuff would curve on the joint faces [**58**], with loss of the truly circular form, while in a lagged-up pattern changes due to desiccation and moisture are localised. How this method is embodied in a pattern column is shown in **59**, which represents such a half pattern laid open in the joint face, with the cross bars to which the lags are attached. Methods of fitting flanges, end core prints, and mouldings are also indicated.

Segmental Construction. This is an exceedingly important detail of pattern-work, being adopted for nearly all patterns of sweeped and annular form, such as curved portions generally, and for the rims of wheels and pulleys of all dimensions. In principle it is paralleled by the disposition of bricks in a wall, in superimposed layers, with end joints alternating. The segments are sawn out, jointed, glued in layers, and frequently strengthened by the insertion of wooden pegs. The latter would not be employed but for the fact that the rough usage to which patterns are subjected in the foundry and the moisture of the sand are in time liable to overcome the adherence of the glue alone.

Example of Segmental Work. A typical example of segmental work is that afforded by the ring [**60**], for any common wheel. It is easy to see what would happen if such a ring as this were made of solid wood. However hard, close grained, and well seasoned it might be, it would not only become elliptical by the alternate wetting and drying to which it is subjected in the foundry, but the short grain would snap, and the pattern be falling to pieces before half a dozen moulds had been made from it. But being built up, there is no tendency to depart from the circular form; the only shrinkage which can take place being of a local character—namely, in the width of each individual segment, and in their thicknesses, the amounts of which are almost inappreciable.

Each glued segment binds its fellow, and the wheel is as strong as a wooden structure of this form can possibly be made, while the application of varnish prevents the glue from becoming moistened and working out of the joints by the action of the damp foundry sand. The drawing [**61**] illustrates the commencement of the building up, the first segments being glued to the face plate with paper joints. A pattern of a sheave pulley built up in this way is shown in plan, and half external view and half sectional view in **62**, with its dividing joint along *a—a*. The arms, also divided, it will be noted, are made of three separate pieces, lap-jointed together with "halvings," and are therefore strong, the grain being straight in each. A



BROAD TYPES OF PATTERN CONSTRUCTION

53. Example of open joints and boxing-up **54.** Boxing-up **55.** Improper method of boxing-up **56.** Halvings **57.** Lagged-up column **58.** Warping of solid timber **59.** Complete pattern column lagged up, with attachments **60.** Ring built in segments **61.** Beginning of the work **62.** Complete sheave-pulley pattern, built up in segments **63.** Pipe pattern, jointed along the centre **64.** Unjointed pipe pattern **65.** Iron pattern, unjointed

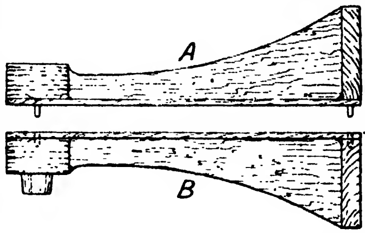
built-up wheel is the perfection of pattern work, and will stand moulding from hundreds of times.

Metal Patterns. We have already mentioned the fact that metal is used for some patterns in preference to wood, with the reason for its employment. Cast iron, brass, white metals, are pressed into service. Always in such cases a pattern of wood or of plaster has to be made first, having double shrinkage, one shrinkage for the metal pattern, the other for the castings moulded from the latter. Generally, too, allowances must be made on the metal pattern for filing or tooling, to produce surfaces smooth enough and sufficiently accurate for moulding from. Lead and leather are both used frequently in patterns, the first-named for those which have to be of curved and awkward forms, the lead pattern being used from which to mould one in iron or brass. Also, the two materials are employed largely for lining up and thickening portions of patterns to effect slight alterations in them.

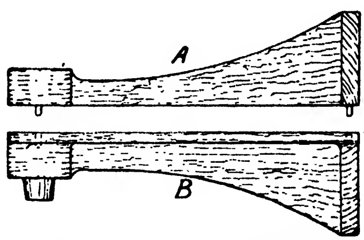
Varnish. Patterns are varnished to protect them from the moisture present in the sand, to preserve them, and to facilitate their withdrawal. A plain shellac and spirit varnish is generally used, in its natural yellow colour. Sometimes lampblack is mixed with it, and used on core prints to distinguish them from the other portions. Large cheap patterns are sometimes seared with a hot iron. Large patterns for permanent use are sometimes protected with two or three coats of oil paint.

Jointing Patterns. We will now consider the pattern from the point of view of its delivery from the sand. This, as has been illustrated in the two preceding articles of this course, involves the great question of jointing.

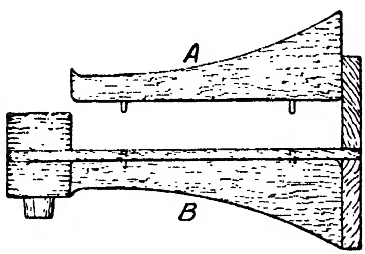
An observant youth on going into a pattern shop or a pattern stores for the first time would at once be struck by the fact that very few of the patterns were whole or entire. The bulk of them, probably nine-tenths of the total number, are pieced up, jointed in some way or another. Sometimes they are divided down the centre only, into two symmetrical halves; sometimes there are several divisions, in planes parallel with each other. Or the pattern, as a whole, is unjointed, but subsidiary portions are jointed in a loose and readily removable fashion. But in all cases means are taken to preserve the due relative positions of the several parts, so that when in their proper places with closed joints there is no risk of those relative positions being changed. The means employed to preserve these relationships are seen to be pins, or dowels, dovetails, and skewers, or wires.



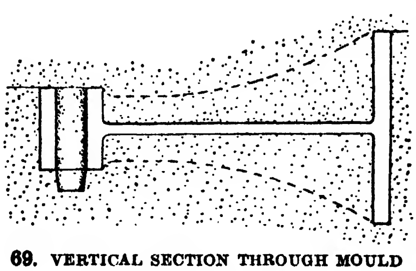
66. METHOD OF JOINTING BRACKET PATTERN



67. METHOD OF JOINTING BRACKET PATTERN



68. METHOD OF JOINTING BRACKET PATTERN



69. VERTICAL SECTION THROUGH MOULD OF BRACKET PATTERN

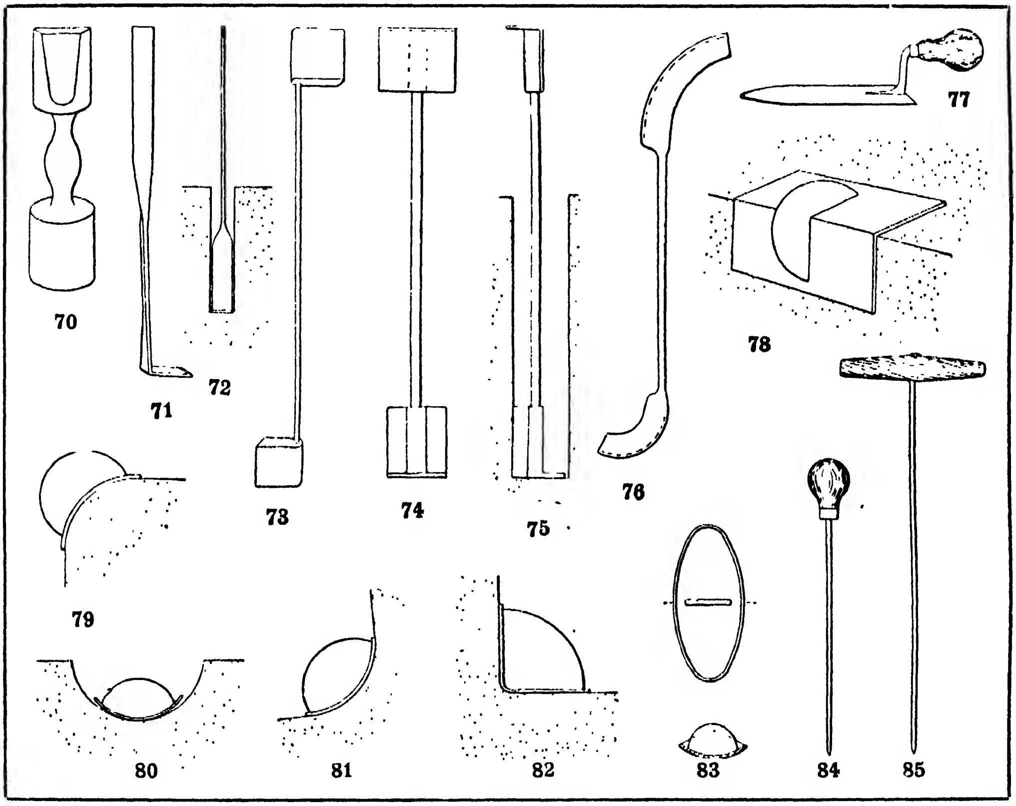
Reasons for Jointing. If, from the pattern shop the student goes into the foundry, he soon learns the reasons for this jointing—that without it there would, in many cases, be no possibility of withdrawing the patterns without producing violent disturbance and fracture of the sand, quite destructive of its accurate shape and outlines. He sees that the joints in patterns, and in foundry boxes and moulds generally, correspond, but that in others they do not, except in an approximate fashion. In this way he learns the difference between the plain and obvious joints of boxes, and those of sloping joints, drawbacks, and rings of sand carried on grids. In many cases, also, though joints are not absolutely necessary for the proper withdrawal of the pattern, they are seen to be nevertheless desirable, either for the easier cleaning up of the mould, or for the insertion of cores, or to save additional jointing of moulding-boxes. Further, he observes the reason why dowels, dovetails, and skewers are employed, since without them the pattern sections would become moved relatively to one another in the mould by the process of ramming; hence he will conclude that proper jointing lies at the very foundation of the art and trade of pattern-making, and that there is only one reason for the jointing of patterns—namely, to facilitate the clean withdrawal of the pattern sections from the mould.

Varieties of Joints. The plainest and commonest joints are those which coincide precisely with the joint of the mould and of the moulding-box. This type of pattern

is represented by the cylinder, pipe, or column, jointed longitudinally down the central plane or axis. This divides the pattern into symmetrical halves, one of which goes in the bottom, and one in the top box. Fig. **63** is a pattern of this type, jointed and dowelled in the plane *a—a*. Nine-tenths of patterns of this type used for jobbing and casual orders, and large quantities for standard work—those of very small diameter excepted—are jointed in this way.

The exceptions to the common practice are several, but may be included under two heads, as follows: Patterns unjointed, being so made with a view to economy, and patterns made brassfounders do much less jointing than ironfounders, employing bottom, or joint boards, by which the labour of making sand joints by hand afresh for every mould is saved. Fig. **65** shows a pattern made of iron for producing the same moulds as **63** and **64**. It is cast hollow, to lighten it, and the top flange, of wood, is left loose. Such a pattern is generally turned smooth in the lathe.

There is a good deal of give and take in moulding and pattern making. The bracket pattern [**66—68**] illustrates the fact that patterns and moulds alike might be equally well jointed in three different ways, and this is only typical of



MOULDERS' TOOLS

70. Small bench rammer **71.** Cleaner **72.** Cleaner in use **73.** Another form of cleaner **74** and **75.** Boss tool **76.** Flange bead **77.** Trowel **78.** Square-corner sleeker **79.** Round-corner sleeker **80** and **81.** Pipe smoothers **82.** Square-corner sleeker **83.** Button or bacca-box smoother **84** and **85.** Vent wires

unjointed either in order to prevent risk of lapping joints in their castings, or to maintain the maximum strength possible. Thus, the pattern is often made as in **64**, solidly, but leaving the top halves of the flanges loose, for reasons given in a previous section. In **63** the pattern joint coincides absolutely with that of the mould; in **64**, the two only match at the jointing of the flanges, yet the joint of the mould must be carried along the central, or longitudinal, plane of the pipe, just as in **63**.

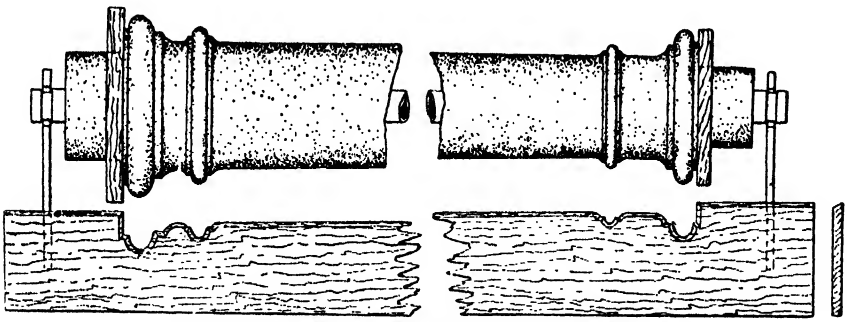
Jointless Patterns. This device of making patterns without joints is adopted generally in those made of metal. The alternatives in practice that are for ever occurring. The drawings are almost self-explanatory. In **66** the jointing of pattern and mould alike takes place in a horizontal plane that coincides with the exact centre of the bracket. In **67** the joint is made on the top face of the main web, the advantage of which is a slightly stronger pattern, because the web or plate is in one thickness. In both cases the portions A A come in the top box, and B B in the bottom. In **68**, the top rib only is dowelled loosely, and here the rib is the only portion that is left in the top. The mould joint, instead of being in a strictly horizontal plane, follows the outlines

set vertically, having an edge cut to any required profile, and chamfered, and fastened to a spindle at a certain definite distance from the centre of rotation—works in loam are commonly struck or swept thus—or, secondly, by the revolution of a horizontal core-bar, with its covering of haybands and loam against a similar board laid on trestles. Cores are struck up in this way. Or, again, by the guidance of a templet or strickle against the edge of a plate, or a rod of iron, either cores or loam patterns whose outlines' are not symmetrical in the longitudinal direction are readily struck up. In each case the pattern-makers' work is almost nil, while that of the moulder is rendered more responsible. The importance of an intimate knowledge of the entire details of sweep-work, including the choice of the best and most economical methods of striking up, the most practicable details, the conditions under which moulds and cores must be made is therefore indispensable.

Green Sand Sweeping. Figs. 89 and 90 llustrate how a mould is swept up in green sand. It is a large dished cover, the pattern for which would be expensive, but the boards would cost little, while the time occupied in sweeping need not be much greater than would be spent in moulding from a pattern.

Two striking-boards are required. A in 89 sweeps a dummy mould upon which the top box is rammed; B then is substituted to strike the bottom directly. Or the top might be swept directly by a board cut the reverse to A, the top mould being then turned over on the bottom one. Or the convex side of the cover might be moulded downwards instead of upwards.

Cylindrical Sweeping. Cases that are always occurring are the sweeping of cylindrical cores, loam patterns, and loam moulds, with or without extraneous fittings. In each of these, loam is struck against the edges of boards which are the counterparts of the forms struck, or the profile boards are worked over the loam. In the making of wooden patterns or core boxes of large dimensions, all intricate and involved outlines, curves, and mouldings materially increase the expense of pattern work, often rendering it out of all reasonable proportion to the cost of the casting or castings required. But the expense of cutting the striking edge of a board or boards is a mere trifle, and is not affected at all by the question of diameter, that being then a question of moulder's labour and not of pattern work at all. The question of relative cost between striking-boards and complete patterns would be usually one of a few shillings versus many pounds.



93. A LOAM PATTERN MADE BY SWEEPING UP

Examples of Sweeping-up. Fig. 91 illustrates the sweeping up of a core A, for a fusee drum, against a board B; C being the core-bar, pierced with vent holes. The outline of the pattern is seen marked upon the board as a guide to the moulder in setting the core in place. This device is a good one to adopt. Fig. 92 shows a core in section for an air vessel, with its board. The central core-bar is seen to be encircled with plates to retain the haybands, on and among which the loam is plastered. The end plates have prods to carry the loam there. Fig. 93 is a column pattern swept in loam against its board, the board being shown withdrawn away. Here the top and bottom flanges are made separately in wood, and slipped on the loam body. The iron bar seen projecting at the ends has journals turned on it to run in the core trestles. The body of the loam is built up on plates and hayropes as in 92.

Work which is in the main symmetrical, as in 93, often includes other attachments of more or less irregular outline to be made as separate parts and fitted to the struck-up pattern, core or mould. The flanges in 93 are a mere nothing in comparison with the fittings to, say, a hydraulic cylinder. Sometimes these are so numerous that it becomes a question whether in view of the time occupied in making and fitting such pieces to the circular portion of a mould —with the possible risk of their becoming displaced—it is not cheaper to make an entire pattern of wood. Such jobs do occur frequently, occupying the border-line between economical and non-economical striking up of work.

Sweeping in Loam. This involves the employment of bricks as a skeleton framework to support the loam, and the use of iron rings to carry the bricks. This is a distinct branch of moulding, involving very different methods of treatment from those of green sand work, and it is usually practised by men who do not work in green sand. The main outlines of the moulds are produced by means of a board or boards having chamfered edges, and attached to a central bar turning in a socket. In many, or in most cases, there will be portions that

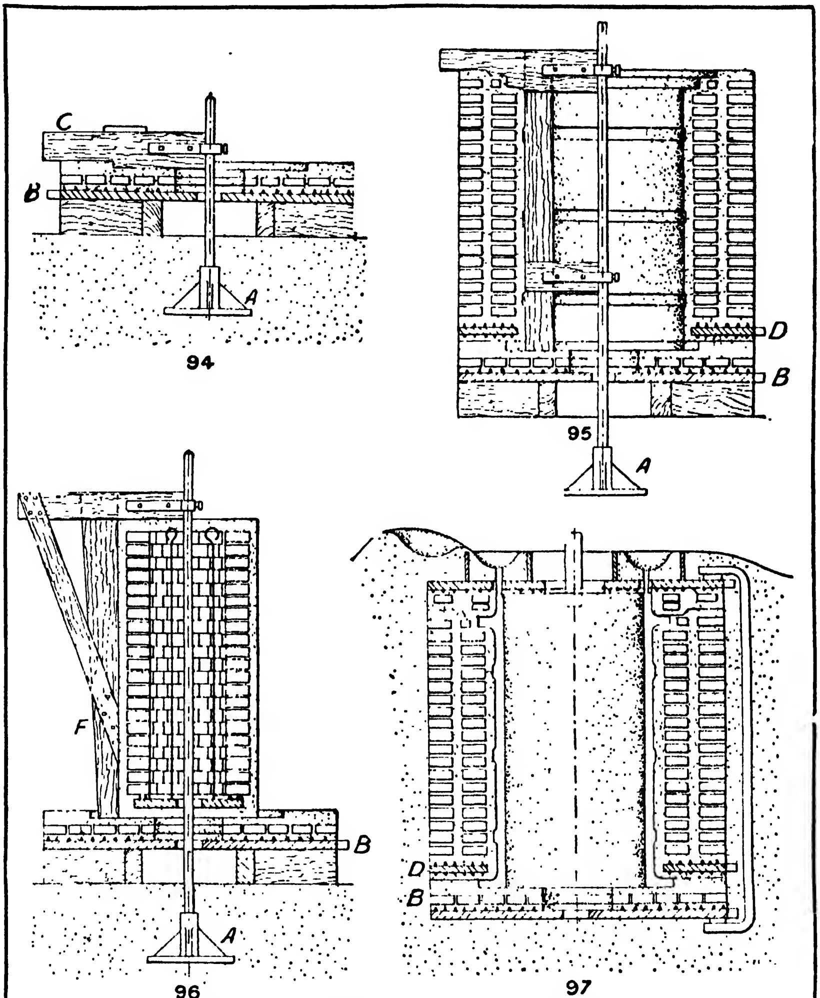
cannot be swept, but for which pattern pieces will be wanted, and these are embedded in the loam, being set by measurement, and so constructed as to be readily withdrawn after the loam has become partially or wholly set.

The brickwork skeleton or framework of a loam mould which forms the backing for the loam is cemented together also with loam, and the spacing of the joints is left wide to permit of due shrinking of the mould, and of sufficient venting spaces. In situations where the shrinkage is considerable, or where it is necessary to cut away portions of the mould, or where a portion of the mould has to be rapidly removed soon after casting, loam bricks—that is, loam moulded in the form of bricks and dried—are used.

Loam moulds generally make the best castings, because, owing to the moulds being thoroughly dry, there is much less gas generated than in green sand moulds; and the surface of the mould is hard, and therefore better able to withstand pressure of metal.

Cylinder Moulding in Loam. Figs. 94 to 97 illustrate the moulding of a plain cylinder in loam. The socket is seen at A, carrying the striking bar to which the boards are attached. The plates, bricks, and loam are all shown. Briefly, the sequence of operations is as follows:

The base of the mould is the plate (B in 94) prodded, and which, being bricked over, receives the loam, swept to outline with the board (C) that forms the bottom flange. This is then dried in the stove. Upon it another plate (D) has to be carried to sustain the outside of the mould, and this plate has to be swept over on both sides, the lower side to make a joint with the loam on B. This involves sweeping, drying, and turning over into place in order that the outer mould shall be built up on it, in which position it is shown in 95. As the loam would tumble down and fill up the flange already swept, this is temporarily filled with sand [95] during the building up of the bricks on D, and the sweeping of the mould with the board (E). This is then dried while the core, and the top, or cope, is being swept. The core is built around bricks on a plate [96] with lifting eyes, by the sweeping board (F). The cope is swept up similarly to the bottom [94], and dried and turned over into place, after the insertion of the core [97], completing the mould. The top and bottom plates being clamped or bolted together fasten the mould securely, and the annular pouring basin is made within an iron ring on the top plate [97].



STAGES IN SWEEPING UP A LOAM MOULD

JOSEPH G. HORNER

German: Pronouns and Strong Ve bs. Spanish: The Use of the Subjunctive. French: Relative and Interrogative Pronouns.

GERMAN

Continued from page 2633

By P. G. Konody and Dr. Osten

XLVI. Relative Pronouns. These are:

(*a*) der, die, das, } who, which, *or*
(*b*) welcher, welche, welches, } that
(*c*) wer, was, who, what

They refer to a person or matter already mentioned, and help to form the relative clause. Examples: ich sah einen Mann, der (or welcher) ein Gewehr trug, I saw a man who carried a rifle; auf dem Tische stand eine Flasche, welche leer war, on the table stood a bottle which was empty, etc.

1. The pronouns (*a*) take the inflections of the demonstrative pronoun der, die, das [see XXXV.]; but the genitive plural of the relative pronoun is *always* deren.

Singular.	*Singular.*
(*a*) 1. der, die, das	(*b*) 1. welcher, welche, welches
2. dessen, deren, dessen	2. welches, welcher, welches
3. dem, der, dem	3. welchem, welcher, welchem
4. den, die, das	4. welchen, welche, welches
Plural.	*Plural.*
1. die 2. deren	1. welche 2. welcher
3. denen 4. die	3. welchen 4. welche

The genitive singular welches, welcher, welches, is antiquated and generally replaced by dessen, deren, dessen. Similarly the genitive plural welcher is always replaced by deren: das Kind, dessen Eltern ich kenne, the child whose parents I know; kennen Sie die Frau, deren Kind krank ist? do you know the woman whose child is ill? Wir begrüßten die Soldaten, deren Pferde staub'bedeckt' waren, we greeted the soldiers whose horses were covered with dust [dust-covered]. Zu den Vorzügen, deren sich England erfreut, gehört die gute geogra'fische Lage, one of the advantages which England enjoys, is her good geographical position [literally: to the advantages, of which England enjoys, belongs her good, etc.].

(*c*) The declension of the relative pronouns wer and was follows that of the interrogative pronouns similarly pronounced [see XXXIX]. Wer is used instead of derjenige, welcher (he who), and was instead of dasjenige, welches (that which): Wer Pech angreift, besudelt sich (proverb), who messes with pitch may dirty himself. Ertragen muß man, was der Himmel sendet, one must endure what Heaven sends [decrees].

2. The choice of welcher or der depends chiefly on considerations of euphony; but the relative pronoun der, die, das must be used where the relative clause refers to a personal pronoun: Du, der mich kennt, thou who knowest me; sie, der ich es sagte, she to whom I told it, etc. Welcher, welche, welches are also used as attributive adjectives: Er sandte uns Blumen, welche zarte Aufmerksamkeit uns mit Freude erfüllte, he sent us flowers, which delicate attention filled us with joy.

XLVII. Indefinite Pronouns.

man, one, people	etwas, something
jemand, somebody	nichts, nothing
niemand, nobody	einer, one, someone
jedermann, everybody	keiner, no one
jeder, everyone	

Man is only used in the nominative and is replaced in the other cases of the singular by the corresponding cases of ein or einer (one), which is declined like the indefinite article: 2. eines, 3. einem, 4. einen. Jemand has the same declensive terminations: 2. -(e)s, 3. -em, 4. -en; jedermann and niemand take an -s in the genitive and remain unaltered in the other cases; niemand may also take -em in the dative and -en in the accusative; einer, keiner, jeder are declined like the demonstrative pronoun dieser, -e, -es [see XXXV]; etwas and nichts are not subject to declension. In poetic language the abbreviation was is sometimes used for etwas: Wir sind zu (et)was Besserem geboren, we are born for something better.

Table of all Pronouns.

1. *Personal*	ich, du, er, sie, es, wir, ihr, sie.
2. *Possessive*	mein, dein, sein, ihr, unser, euer, ihr.
3. *Demonstrative*	der, die, das; dieser; jener; solcher; derjenige; derselbe.
4. *Interrogative*	wer, was; welcher; was für ein.
5. *Relative*	der, die, das; welcher; wer, was.
6. *Indefinite*	man, jemand, niemand, jedermann, etwas, nichts, einer, keiner, jeder.

XLVIII. Strong Verbs. The strong verbs on page 2761 with the stem-vowel -ä-, -ü-, -au-, -e-, -i-, and -ie change these in the imperfect and past participle into -o-.

EXAMINATION PAPER

Exercise 1 (On the use of the relative pronoun).

to marry, hei'raten	shipwreck, Schiffbruch (*m.*)
married, verheiratet	to perish, um'kommen
ill, krank	to lead, führen
to meet, begeg'nen	goodness, Güte (*f.*)
generally, all'gemein	

I know a man who married; I spoke to (mit) the woman whose husband is ill; these are children whom we met yesterday in the forest. Do you know the girls whose brothers are playing [play] tennis? I met the woman whose husband perished in the shipwreck; this is the boy who led me through the forest: he is a man whose goodness is generally known.

Exercise 2 (*a*). Change the imperfect and past tenses into the present:

Der Soldat focht tapfer; der Wind bewegte The soldier fought bravely; the wind moved die Zweige der Bäume; der Sonnenun'tergang bewog mich the branches of the trees; the sunset induced me

INFINITIVE		PRESENT TENSE I., II., III. Singular	IMPERFECT Indicative	IMPERFECT Conjunctive	IMPERATIVE	PAST PARTICIPLE
bewe'gen *	to move, induce	ich beweg-e, -st, -t	ich bewog	ich bewöge	beweg(e)	bewogen
fechten	to fight	„ fechte, fichtst, ficht	„ focht	„ föchte	ficht	gefochten
flechten	to plait, twist	„ flechte, flichtst, flicht	„ flocht	„ flöchte	flicht	geflochten
heben	to lift	„ hebe, hebst, hebt	„ hob (hub)	„ höbe	heb(e)	gehoben
melken	to milk	„ melk-e, -st, -t	„ molk	„ mölke	melk(e)	gemolken
pflegen †	to indulge in, to be given to	„ pfleg-e, -st, -t	„ pflog	„ pflöge	pfleg(e)	gepflogen
quellen ‡	to well, to flow	„ quelle, quillst, quillt	„ quoll	„ quölle	quill	gequollen
scheren	to shear	„ schere, scherst, schert	„ schor	„ schöre	scher(e)	geschoren
schmelzen	to melt	„ schmelze, schmilzest, schmilzt	„ schmolz	„ schmölze	schmilz	geschmolzen
schwellen §	to swell	„ schwelle, schwillst, schwillt	„ schwoll	„ schwölle	schwill	geschwollen
weben	to weave	„ web-e, -st, -t	„ wob	„ wöbe	web(e)	gewoben
erwägen	to consider, ponder	„ erwäg-e, -st, -t	„ erwog	„ erwöge	erwäg(e)	erwogen
gähren ‖	to ferment	„ gähr-e, -st, -t	„ gohr	„ göhre	gähr(e)	gegohren
schwären	to fester	„ schwär-e, -st, -t	„ schwor	„ schwöre	schwär(e)	geschworen
wägen ¶	to weigh, balance	„ {wäg-e, also wieg-e,} -st, -t	„ wog	„ wöge	wäg(e)	gewogen
biegen	to bend	„ bieg-e, -st, -t	„ bog	„ böge	bieg(e)	gebogen
bieten	to offer, tender	„ biet-e, -est, -et	„ bot	„ böte	biet(e)	geboten
fliegen	to fly	„ flieg-e, -st, -t	„ flog	„ flöge	flieg(e)	geflogen
fliehen	to flee, escape	„ flieh-e, -st, -t	„ floh	„ flöhe	flieh(e)	geflohen
fließen	to flow	„ fließ-e, -est, -t	„ floß	„ flösse	fließ(e)	geflossen
frieren	to freeze, to be cold	„ frier-e, -st, -t	„ fror	„ fröre	frier(e)	gefroren
gebie'ten	to command	„ gebiet-e, -est, -et	„ gebot	„ geböte	gebiet(e)	geboten
genie'ßen	to enjoy	„ genieß-e, -est, -t	„ genoß	„ genösse	genieß(e)	genossen
gießen	to pour	„ gieß-e, -est, -t	„ goß	„ gösse	gieß(e)	gegossen
glimmen	to glow	„ glimm-e, -st, -t	„ glomm	„ glömme	glimm(e)	geglommen
kriechen	to creep, crawl	„ kriech-e, -st, -t	„ kroch	„ kröche	kriech(e)	gekrochen
riechen	to smell,	„ riech-e, -st, -t	„ roch	„ röche	riech(e)	gerochen
schieben	to shove, push	„ schieb-e, -st, -t	„ schob	„ schöbe	schieb(e)	geschoben
schießen	to shoot	„ schieß-e, -est, -t	„ schoß	„ schösse	schieß(e)	geschossen
schließen	to shut, lock	„ schließ-e, -est, -t	„ schloß	„ schlöße	schließ(e)	geschlossen
sieden	to boil, seethe	„ sied-e, -est, -et	„ sott	„ sötte	sied(e)	gesotten
sprießen	to sprout	„ sprieß-e, -est, -t	„ sproß	„ sprösse	sprieß(e)	gesprossen
stieben	to scatter, disperse	„ stieb-e, -st, -t	„ stob	„ stöbe	stieb(e)	gestoben
verbie'ten	to forbid, prohibit	„ verbiet-e, -est, -et	„ verbot	„ verböte	verbiet(e)	verboten
verdrie'ßen	to vex, annoy, grieve	es verdrießt	es verdroß	es verdrösse	—	verdrossen
verlie'ren	to lose	ich verlier-e, -st, -t	ich verlor	ich verlöre	verlier(e)	verloren
ziehen	to pull, draw	„ zieh-e, -st, -t	„ zog	„ zöge	zieh(e)	gezogen
betrü'gen	to cheat	„ betrüg-e, -st, -t	„ betrog	„ betröge	betrüg(e)	betrogen
küren	to choose	„ kür-e, -st, -t	„ kor	„ köre	kür(e)	gekoren
trügen	to deceive, delude	„ trüg-e, -st, -t	„ trog	„ tröge	trüg(e)	getrogen
klimmen	to climb	„ klimme-, -st, -t	„ klomm	„ klömme	klimm(e)	geklommen
saufen	to drink, tipple	„ sauf-e, säufst, -t	„ soff	„ söffe	sauf(e)	gesoffen
saugen	to suck	„ saug-e, -st, -t	„ sog	„ söge	saug(e)	gesogen

* In the sense of "to induce," bewegen is *strong:* ich bewog ihn, I induced him; in the sense of setting in motion, it is weak: wir bewegten uns, we moved; das Meer war bewegt, the sea was agitated.

† In the sense of to attend to, to carry on, to manage, to indulge in, pflegen is strong; in the sense of to nurse, to tend, to cultivate, it is weak (imperfect: ich pflegte; past participle: gepflegt).

‡ Weak in the sense of exposing something to humidity: die Erbsen wurden gequellt, the peas were soaked.

§ Weak as transitive verb: der Regen hat den Bach angeschwellt, the rain has swelled the brook.

‖ Weak, when used figuratively: das Land gährte, the country was in a state of ferment.

¶ Weak in the sense of motion (swaying gently): Sie wiegte sich im Tanze, she moved gracefully in dancing.

um'zukehren; das Mädchen hat einen Kranz geflochten;
to turn; the girl has bound a wreath;
er hob das Faß; die Schäfer haben
he lifted the barrel; the shepherds have
die Schafe geschoren; die Knaben flohen;
shorn the sheep; the boys fled;
das Wasser floß rasch.
the water flowed quickly.

(*b*). Change the present tense into the imperfect and past.

Sie genießen nicht die Schönheit der Landschaft;
You do not enjoy the beauty of the landscape;
die Schlange kriecht über den Weg; das
the snake crawls across [over] the road; the
Wasser siedet; der Jäger schießt vorzüglich;
water boils; the gamekeeper is a splendid shot;
ich verliere mein Geld; ich verbiete Ihnen dies ernst-
I lose my money; I earnestly forbid you [to do]
lich; die Blumen riechen gut; ich glaube
this; the flowers smell beautifully; I believe
der Mann betrügt mich; die Pflanze saugt ihre
the man is cheating me; the plant sucks its
Nahrung aus dem Boden.
nourishment from the soil.

EXERCISE 3. Insert the missing indefinite pronouns:

Er ist .... Freund. Wo .... geboren ist,
He is everybody's friend. Where one is born
dort heimelt es (4) ..... an; es ist nicht ....
[there] one feels at home; it is not everybody's
Geschmack zu streiten; haben Sie .... gehört?
taste to quarrel; have you heard something?
Nein, ich habe .... gehört; ich glaube (3) ......,
No, I have heard nothing; I believe nobody
den ich nicht kenne.
whom I do not know.
.... Hand muß dabei im Spiele gewesen sein.
Somebody's hand must have been in the game.
(Somebody must have had his finger in the pie.)

KEYS TO EXERCISES [PAGE 2632]

EXERCISE 1 (*a*). *Imperfect:* Ich blieb zu Hause; du pfiffst laut; das Mädchen rieb die Diele; wir schrieben Briefe; das Kind schrie entsetzlich; die Männer schwiegen; wir stiegen auf den Berg; ich verzieh Ihnen; der Hirt trieb das Vieh auf die Weide; der Knabe wies mir den Weg ins Dorf.

Perfect: Ich bin zu Hause geblieben; du hast laut gepfiffen: das Mädchen hat die Diele gerieben; wir haben Briefe geschrieben; das Kind hat entsetzlich geschrieen; die Männer haben geschwiegen; wir sind auf den Berg gestiegen: ich habe Ihnen verziehen; der Hirt hat das Vieh auf die Weide getrieben; der Knabe hat mir den Weg ins Dorf gewiesen.

(*b*). Ich beiße in den Apfel; weshalb bleibst du nicht bei uns? Der Künstler ergreift das Instrument; wir leiden große Schmerzen; der Kutscher pfeift eine Melodie; das Mädchen reißt eine Rose vom Zweige; die Sonne scheint hell; der Bettler schleicht an der Mauer hin; was schreiben Sie mir? Der Mann und die Frau streiten heftig.

EXERCISE 2 (*a*). Wo sind meine Tintenfässer? Ich kann nicht meine Handschuhe finden. Geben Sie mir meine Taschentücher. Die Messerklingen sind gebrochen; die Pfauenfedern sind schön; die Armbänder waren aus Gold; die Fußböden waren mit Teppichen belegt; die Weingläser sind leer; die Goldschmiede haben schöne Ringe. Aus welchem Stoffe sind Ihre Halsbinden? Geben Sie mir gefälligst die Obstmesser.

(*b*) Der Singvogel zieht im Herbst nach dem Süden; der seidene Regenschirm ist nicht sehr haltbar; das Augenlid ist geschwollen; ich kaufte eine Erdbeere Wohin führt dieser Waldpfad; Ich besitze einen Winterrock.

(*c*). Die Hauptleute kommandierten die Truppen; ich sandte die Dienstmänner nach Hause; Kaufleute müssen rechnen können; Staatsmänner sollten nicht irren; junge Ehemänner sind gewöhnlich nachgiebig.

(*d*). Zehn Pfund Kaffee, zehn Bund Stroh, zehn Faß Petroleum, zehn Buch Papier, zehn Sack Reis, zehn Flaschen Wein, zehn Ballen Wolle, zehn Tonnen Kohle, zehn Wochen, zehn Stunden, zehn Meilen, zehn Kubik-Fuß Holz, zehn Kisten Zucker.

Continued

SPANISH

By José Plá Cárceles, B.A.

Translation of "To" "To," meaning "in order to," in front of an infinitive is generally translated by *para*, unless it is preceded by part of a verb of motion, when it is always rendered by *á*.—it is too late to protest, *es demasiado tarde para protestar;* he has gone to protest, *ha ido á protestar*.

Other important verbs after which "to" is rendered by *á* are:

to learn	*aprender*	to refuse	*negarse*
to compel	*obligar*	to teach	*enseñar*
to begin	*empezar*	to commence	*comenzar*
to submit	*someterse*	to authorise	*autorizar*
to get used	*acostumbrarse*		
to invite	*invitar convidar*		

There are certain verbs after which "to" is not translated at all. The principal are:

to promise	*prometer*	to allow	*permitir*
to hope	*esperar*	to like	*gustar*
to be able	*poder*	to want	*querer*
to wish	*desear*	to be sorry	*sentir, pesar*
to know how to	*saber*		
to intend	*intentar*		

Whenever the conjunction *y* (and) occurs immediately before a word beginning with *i* or *hi*, it is changed into *é* for the sake of euphony. —*España é Inglaterra*, Spain and England. For the same reason *ó* (or) becomes *ú* in front of a word beginning with *o* or *ho*.—*setenta ú ochenta casas*, seventy or eighty houses.

"But," after a Negative Sentence. The conjunction *pero* (but) after a negative sentence must be changed into *sino*, unless it is followed by a verb.—*no he recibido el dinero, sino solamente los intereses*, I have not received the money, but only the interest; *no ha recibido el dinero todavía, pero ya ha cobrado las intereses,* he has not received the money yet, but he has already cashed the interest.

EXERCISE XXXVI

a street	*una calle*	the square	*la plaza*
to walk	*pasear*	to pay a visit	*visitar*
besides	*además*	to consult	*consultar*
to finish	*acabar*	to skate	*patinar*
ice	*hielo*	magazine	*revista*

to take	*tomar*	bookcase	*estante*
the fiancé	*el novio*	to ask for	*pedir*
certainly	*naturalmente*	tramway	*tranvía*
a prayer	*una oración*	the hymn	*el himno*
infantry	*infantería*	cavalry	*caballería*
a cousin	*un primo*	to undertake	*emprender*

Great Britain, *La Gran Bretaña* Wales, *Gales*
Portuguese, *portugués* Do you? Did you? *¿y Vd.?*
to be very pleased to, *tener mucho gusto en*
the address, *la dirección, las señas*
to keep waiting, *hacer aguardar*
the information, *los informes*
a long time, *mucho tiempo*.

1. How would you like to live in Paris? 2. I should like it very much. 3. What is he in want of? 4. He wants more money to undertake a new business. 5. Do you know your cousin's address in Madrid? 6. His address used to be 103, Murillo Street (*trs.* Street of Murillo, number 103). 7. Mine is 24, Hernán Cortés Square, where I hope to see you soon. 8. Many thanks. I shall be very pleased to pay you a visit next summer. 9. Do you like walking? 10. Yes, but not today; it is very hot, and, besides, I am too tired (fem.). 11. He is now sorry to have accepted the offer without consulting his partners. 12. She always keeps us waiting a long time. 13. How much time do they still want to finish their work? 14. They want another hour. 15 They do not work so quickly as they promised us. 16. Do you know (how) to skate? 17. No; do you? 18. I like skating on the ice. 19. We want another bookcase to put all those magazines in. 20. They have come to explain it to him. 21. Was it very windy in the park this afternoon? 22. Not so much as last Sunday. 23. He will refuse to sign the contract before receiving the information he has asked for. 24. We have invited her fiancé to dine with us. 25. Do you wish to speak to him? 26. He promised to pay us a visit during the winter. 27. Do you allow me to smoke? 28. Certainly! Take one of my cigarettes. 29. I was not able (*no pude*) to understand what he said (imp.). 30. We took a tramway as soon as it began to rain. 31. England, Wales, and Scotland form Great Britain. 32. I do not know how to speak Italian, but I understand it rather well. 33. He is not teaching her Portuguese, but Spanish. 34. Hymns or prayers. 35. Infantry and cavalry.

Subjunctive Mood. This subjunctive mood is more strictly observed in Spanish than in English; it generally implies that the action or state expressed by the verb is not quite certain, as it is when the indicative mood is employed, but merely contingent or doubtful. The following examples will make clearer the import of the subjunctive: Indicative—*Cuando lo VEO le hablo,* when(ever) I see him I speak to him; Subjunctive—*Cuando lo VEA le hablaré,* when I may see him I shall speak to him. Indicative—*Aunque HA estudiado mucho sabe muy poco,* although he has studied a great deal he knows very little; Subjunctive—*Aunque HAYA estudiado mucho sabe muy poco,* although he may have studied a great deal, he knows very little. As will be seen, the actions which in these sentences are positively expressed by the indicative mood (*veo* and *ha estudiado*) become at once doubtful when the subjunctive is used.

The Tenses of the Subjunctive. The simple tenses of the subjunctive mood are three: present, imperfect, and future. Although a construction of the infinitive with the auxiliaries "may," "might," "would," is sometimes an exact equivalent of the Spanish subjunctive, this is far from being the case always. It would therefore be utterly misleading to attach any general or permanent translation to the above tenses, whose employment does not really depend upon the wording of the English sentence, but must be regulated by certain fixed principles which are stated at a later stage.

Present Subjunctive. The first conjugation verbs form their present subjunctive by adding to the stem the terminations *e, es, e, emos, eis, en.* Verbs of the second and third conjugations add the terminations *a, as, a, amos, ais, an.*

SUBJUNCTIVE MOOD

	Singular	*Plural*
1.	*compr-e*	*compr-emos*
	compr-es	*compr-eis*
	compr-e	*compr-en*
2.	*beb-a*	*beb-amos*
	beb-as	*beb-ais*
	beb-a	*beb-an*
3.	*cumpl-a*	*cumpl-amos*
	cumpl-as	*cumpl-ais*
	cumpl-a	*cumpl-an*

The present subjunctive of *ser, estar, haber,* and *tener* is as follows:

sea	*esté*	*haya*	*tenga*
seas	*estés*	*hayas*	*tengas*
sea	*esté*	*haya*	*tenga*
seamos	*estemos*	*hayamos*	*tengamos*
seais	*esteis*	*hayais*	*tengais*
sean	*estén*	*hayan*	*tengan*

Note that the third person singular and the first and third persons plural of the present subjunctive are the same as the corresponding ones of the imperative (see page 2114). This is also the case when the imperative of a verb happens to be irregular.

EXERCISE XXXVII

Form the present subjunctive of the following verbs:

1. *cambiar.* 2. *coser.* 3. *vivir.* 4. *vender.* 5. *alquilar.* 6. *haber.* 7. *escribir.* 8. *ser.* 9. *contestar.* 10. *comer.*

KEY TO EXERCISE XXXV

1. Hay muchas razones para suponer eso. 2. Había demasiada gente en la cubierta. 3. ¿Hay alguien en ese camarote? 4. Creo que sí, pero hay varios libres (*or* desocupados)

á proa. 5. No hay tiempo que perder. 6. Habrá más pasado mañana. 7. Solamente llovió las dos primeras noches. 8. ¿ Graniza á menudo en su país ? 9. Muy raramente ; la última vez que granizó fué hace cinco años. 10. Ayer hizo un día espléndido. 11. ¿ A que hora amanece ahora ? 12. Según el almanaque, sale el sol á las seis menos cuarto. 13. En invierno anochece más temprano que en verano. Los días son muy cortos. 14. Hace demasiado calor en esta habitación ; haga Vd. el favor de abrir esa ventana. 15. Con mucho gusto, pero hará demasiado frío. 16. No importa ; muchas gracias de todos modos. 17. Haga el favor de prestarme un paraguas ; parece que vá á llover. 18. Creo que ya está lloviznando. 19. ¿ Hizo sol durante sus vacaciones de verano ? 20. Al contrario ; tuvimos niebla casi todos los días. 21. Ahí está el automóvil de su amigo. 22. Será necesario explicárselo otra vez. 23. Debe haberlo olvidado. 24. Le ví hace dos semanas. 25. Debemos aguardar su respuesta para ver de quien es la culpa. 26. Deberían pagarnos en oro. 27. ¿ No cree Vd. que debería poner el asunto en manos de mi abogado ? 28. Naturalmente, sería mucho más seguro para Vd.

Continued

FRENCH

Continued from page 2634

By Louis A. Barbé, B.A.

RELATIVE PRONOUNS

There are two forms of relative pronouns, the uninflected and the inflected.

The uninflected relative pronouns are:

qui, who, which, that, whom (after a preposition) ; *que*, whom, which, that ; *quoi*, which ; *dont*, whose, of whom, of which ; *où*, in which, into which, at which, to which, etc.

The inflected relative pronouns are:

lequel (mas. sing.), *lesquels* (mas. pl.), who, whom, which, that ; *laquelle* (fem. sing.), *lesquelles* (fem. pl.), who, whom, which, that.

The definite article is contracted in the same way as when it precedes a noun : *duquel, auquel, desquels, auxquels, desquelles, auxquelles.*

The relative pronoun, whether inflected or uninflected, is of the same gender, number, and person as its antecedent. In the case of the uninflected relative, there is nothing in the pronoun itself to show this agreement ; but it affects the number and person of the verb of which the relative is the subject, and the number and gender of adjectives and past participles referring to the relative : *Les amis qui nous accompagnent connaissent bien Paris,* The friends who accompany us know Paris well.

Il y a dans ce livre une histoire qui est très intéressante, In that book there is a story which is very interesting.

1. *Qui*, as the subject of a verb, may refer to either persons or things :

Le marchand qui vous a vendu ces objets est très accommodant, The shopkeeper who sold you those objects is very obliging ;

Il donne de l'eau à son cheval qui est très altéré, He is giving water to his horse, which is very thirsty.

When preceded by a preposition *qui* refers to persons only. For animals and inanimate objects the inflected relative must always be used after a preposition :

L'enfant à qui tout cède est le plus malheureux, The child to whom everything (every one) yields is the most wretched.

C'est une condition sans laquelle je ne consentirai à rien, That is a condition without which I shall not consent to anything.

2. *Que* is used as a direct object (accusative), and may refer to persons or things :

Voici les amis que nous attendions, Here are the friends we were expecting.

Je lis le livre que vous m'avez prêté, I am reading the book which you lent me.

The *e* of *que* is elided before a word beginning with a vowel or unaspirated h.

The *i* of *qui* is never elided; consequently, *qu'* always stands for *que :*

J'ai reçu la lettre qu'il m'avait promise, I have received the letter which he had promised me.

In English, the relative pronoun has distinct forms for subject and object only when it refers to persons : "who," "whom." When it refers to animals or things, it has only the one form "which" for both cases.

The fruit which is on that tree (nominative).

The fruit which that tree produces (objective).

In French, each case having its special form and not being dependent on position, the object is frequently placed immediately before the verb. Thus, "The fruit which that tree produces" may be rendered either by :

Le fruit que cet arbre produit, or *Le fruit que produit cet arbre.*

In English, the relative pronoun as object is very often omitted. In French it must always be expressed :

The pupil you have scolded, *L'élève que vous avez grondé ;*

The exercises you have corrected, *Les devoirs que vous avez corrigés.*

3. *Quoi* is used as an indirect object—*i.e.*, after a preposition. Its antecedent is rarely a noun, but rather a statement, or some indefinite expression, such as *quelque chose*, something ; *rien*, nothing ; *voilà*, that is :

Il n'y a rien sur quoi l'on ait plus écrit, There is nothing about which more has been written.

Voilà de quoi je voulais vous parler, That is what I wished to speak to you about.

If the antecedent is a noun it is better to use the inflected relative with the preposition :

C'est la chose à laquelle je pense le moins, That is the thing I think least about.

4. *Dont* is equivalent to the relative pronoun and the preposition *de* (of, from), thus:

Le livre dont vous m'avez fait présent, The book of which you have made me a present.

Les amis dont vous avez méprisé les conseils, The friends whose advice you have despised.

In English, the noun dependent on "whose" always follows it, whether it be subject or object, and is never accompanied by a definite article. In French, it has always a definite article, and comes immediately after *dont* only when it is the subject of the relative clause. If it is the object of that clause it comes after the verb:

La maison dont le gérant m'a écrit, The firm whose manager has written to me;

La maison dont j'ai vu le gérant, The firm whose manager I have seen.

When "whose" is preceded by a preposition, it cannot be translated by *dont.* The inflected form of the relative must be used:

La maison au gérant de laquelle j'ai écrit, The firm to whose manager I have written.

5. *Où,* though really an adverb, is frequently used as the equivalent of a relative and one of the prepositions "in," "into," "at," "to," etc.:

La maison où il est né, The house where (in which) he was born.

It may be preceded by *de,* and used instead of *dont,* to indicate "place whence":

Le village d'où nous venons, The village from which we come.

Only *dont,* and not *d'où,* must be used to indicate descent:

La famille dont il descend est honorable, The family from which he descends is honourable.

NOTES. The relative pronoun with *ce* as its antecedent forms the absolute "what":

Ce qui est vrai n'est pas toujours agréable, What is true is not always pleasant.

Je vous répète ce que l'on m'a dit, I repeat to you what I have been told.

Prenez ce dont vous avez besoin, Take what you have need of.

When the verb is in the infinitive, "what" is *que:*

Je ne sais que faire, I do not know what to do.

The demonstratives *celui, celle, ceux, celles,* are used before the relative instead of the English personal pronouns, "he," "she," "they," and also instead of "the one":

Le meilleur ami est celui qui nous dit la vérité, The best friend is he who tells us the truth.

The demonstrative antecedent may be omitted, as in English:

Qui vivra verra, He who lives (long enough) shall see.

When "which" has a whole clause for its antecedent in English, the relative must be preceded by *ce* in French:

J'ai perdu ma valise, ce qui est fort contrariant, I have lost my portmanteau, which is very provoking.

INTERROGATIVE PRONOUNS

The interrogative pronouns are:

Qui? who? whom? *De qui?* whose? *À qui?* whose? *Qu'est-ce qui? Quoi?* what? *Lequel? lesquels?* (mas.), which? which one? *Laquelle? lesquelles?* (fem.) which? which ones? *Que? qu'est-ce que?* what?

1. *Qui,* as an interrogative pronoun, is both subject and object:

Qui vous a donné cela? Who gave you that?

Qui cherchez-vous? Whom are you looking for?

Qui? may be preceded by a preposition:

Pour qui me prenez-vous? For whom do you take me?

There is also a periphrastic form:

qui est-ce qui? who?
qui est-ce que? whom?

Qui est-ce qui vous a donné cela? Who (is it who) has given you that?

Qui est-ce que vous cherchez? Whom are you looking for?

When this form is used no inversion of the subject and verb is required to mark the interrogation.

"Whose?" is never expressed by *dont.* When it denotes ownership and is equivalent to "to whom belongs?" it is rendered by *à qui?*

Whose key is this? *à qui est cette clef?*

In any other case *de qui?* is used:

De qui est-il (le) fils? Whose son is he?

2. *Qu'est-ce qui?* "What" as the subject of an interrogative sentence has only the periphrastic form, *qu'est-ce qui?*:

Qu'est-ce qui vous empêche de venir avec nous? What prevents you from coming with us?

In indirect questions it becomes *ce qui:*

Je vous demande ce qui vous empêche de venir avec nous. I ask you what prevents you from coming with us.

3. *Que?* what? is used as the object or the predicate of a verb:

Que dites-vous? What do you say? *Qu'est-ce?* What is it? *Qu'est-il?* What is he?

Que deviendrons-nous? What will become of us? (What shall we become?)

There are also two periphrastic forms:

Qu'est-ce que? and *qu'est-ce que c'est que?* neither of which requires inversion of subject and verb:

Qu'est-ce qu'il dit? What does he say?

Qu'est-ce que c'est que ça (cela)? What is that?

In indirect questions *qu'est-ce que* becomes *ce que:*

Je vous demande ce que vous faites, I ask you what you are doing.

4. *Quoi?* is usually the indirect object of an interrogative sentence, and is preceded by a preposition:

Avec quoi avez-vous ouvert ce tiroir? With what have you opened that drawer?

It may also be used absolutely as either the subject or the object of a verb understood:

Il y a quelque chose dans ce tiroir. Quoi? There is something in that drawer. What?

J'ai mis quelque chose dans ce tiroir. Quoi? I have put something into that drawer. What?

Quoi? followed by an adjective in the comparative, preceded by *de*, is used as the subject of *est* understood:

Quoi de plus honteux que le mensonge? What more shameful than lying?

Quoi? may also be used, as more emphatic than *que?* with a verb in the infinitive:

Quoi faire? What to do (is to be done)?

5. *Lequel? laquelle? lesquels? lesquelles?* which? which of? express distinction or selection:

Lequel de vos frères vous a écrit? Which of your brothers has written to you?

De ces deux montres laquelle préférez-vous? Of these two watches, which do you prefer?

"What" Relative or Interrogative

The various ways of translating "what," whether relative or interrogative, are:

1. *Quel, quelle, quels, quelles.*

Quel livre lisez-vous? What book are you reading?

Quelle heure est-il? What time is it?

Quels sont les quatre points cardinaux? What are the four points of the compass?

Quelles belles gravures! What fine engravings!

Je ne sais pas quels romans vous avez lus, I do not know what novels you have read.

2. *Qu'est-ce qui, ce qui, ce que.*

Qu'est-ce qui vous empêche de sortir? What prevents you from going out?

Je vous demande ce qui vous empêche de sortir, I ask you what prevents you from going out.

Je sais ce que je veux, I know what I want

3. *Que, qu'est-ce, qu'est-ce que, qu'est-ce que c'est que.*

Que dites-vous? What do you say?

Qu'est-ce? What is it?

Que deviendrons-nous? What will become of us?

Qu'est-ce qu'il dit? What does he say?

Je vous demande ce qu'il dit, I ask you what he says.

Qu'est-ce que la grammaire? What is grammar?

Qu'est-ce que c'est que ça? What is that?

4. *Quoi.*

Avec quoi avez-vous ouvert ce tiroir? With what have you opened this drawer?

Il y a quelque chose dans ce tiroir. Quoi? There is something in that drawer. What?

J'ai mis quelque chose dans ce tiroir. Quoi? I have put something in that drawer. What?

Quoi de plus honteux que le mensonge? What more shameful than lying?

Quoi faire? What is to be done?

Exercise XX.

Vocabulary

abricot **(m.) apricot**
abricotier **(m.) apricot-tree**
aliment **(m.) food (food-stuff), kind of food**
asperge **(f.) asparagus**
avoine (f. s.) oats (pl.)
la bécasse, woodcock
la bécassine, snipe
la betterave, beetroot
le blé, corn
la boucherie, butcher's shop, meat market
le boulanger, baker
le brochet, pike
le brugnon, nectarine
le canard, duck
la carpe, carp
la carotte, carrot
le cerf, stag
la cerise, cherry
le cerisier, cherry-tree
la chair, flesh
le chasseur, sportsman, hunter
le chevreuil, roebuck
le chou, cabbage
le cidre, cider
le coq de bruyère, grouse
le dindon, turkey
eau douce, fresh water
éperlan (m.), smelt
espèce (f.), kind
étang (m.), pond
le faisan, pheasant
la farine, flour
la faux, scythe
la fève, bean
le filet, net
le fruit, fruit
le fusil, gun (fowling-piece)
le gibier, game
le hareng, herring
le haricot, haricot-beans
le lac, lake
le légume, vegetable
le levain, yeast
le lièvre, hare
la ligne, line
la machine, machine, machinery
le maquereau, mackerel
la mer, sea
le merlan, whiting
le meunier, miller
le moissoneur, reaper
la morue, cod
le moulin, mill
le mouton, sheep
la nourriture, food (sustenance)
oie (f.), goose
oiseau (m.), bird
orge (f.), barley
le pain, bread
la pâte, dough
le paysan, peasant
la pêche, peach
le pêcher, peach-tree
le pêcheur, fisher, fisherman
la perche, perch
la perdrix, partridge
la plante, plant
la poire, pear
le poirier, pear-tree
le pois, pea
le poisson, fish
le poisson de mer, salt-water fish
la pomme de terre, potato
le pommier, pear-tree
le potager, vegetable garden, kitchen garden
la poule, fowl
la prune, plum
le prunier, plum-tree
la raie, skate
le raisin, grape
le ruisseau, brook
le sanglier, wild boar
le saumon, salmon
le seigle, rye
la sole, sole
le terrain, plot of ground
la truite, trout
le turbot, turbot
le veau, calf
le verger, orchard
la viande, meat
la viande de boucherie, butcher's-meat
la vigne, vine
le vin, wine
la volaille, poultry

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connu, known
délayé, mixed
différent, different
frais, new (of bread)
fruitier, fruit (fruit-bearing)
principal, principal
rassis, stale

avec, with
oui, yes
pour, for, in order to, to

ajouter, to add
attraper, to catch
changer, to change
cultiver, to cultivate
faucher, to mow
faire, to make
manger, to eat
nommer, to call
tuer, to kill

---

il fait, he makes
il produit, it produces
ils servent, they serve
ils croissent, they grow

Translate into French

[In the following exercise passive forms are to be rendered by *on* and an active verb: "the animals of which the flesh is eaten," *les animaux dont on mange la chair.*]

What are the principal kinds of food which serve for (*à*) the sustenance of man? They are bread, meat, poultry, game, fish and vegetables. What is the plant which is cultivated to make bread (of it)? It is corn. Who cultivates corn? Peasants cultivate it. What are the principal kinds of corn? They are wheat, oats, barley, and rye. Who are those who mow the corn? The reapers. With what? With scythes. Into (*en*) what is corn changed to make bread (of it)? Into flour. Who is it that changes corn into flour? It is the miller. What is a mill? It is the machinery with which the miller changes corn into flour. What is dough? It is flour mixed with water. What is added to dough? Yeast is added to it. Who makes bread? It is the baker who makes bread. What is stale bread? Bread which is not new. What are the animals of which the flesh is eaten? They are the ox, the calf, the sheep. What is butcher's-meat? It is the flesh of domestic animals. What is game? We call game the animals which are not domestic animals and of which the flesh is eaten. What are they? The stag, the roebuck, the wild boar, the hare. Who are they who kill those animals? They are sportsmen. With what do they kill them? With guns. Is the flesh of birds eaten? Yes, there are some birds of which the flesh is eaten. Which? Fowls, turkeys, ducks, and geese. Are there any other birds of which the flesh is good to eat? Yes, there are other birds of which the flesh is good to eat; they are wild birds, such as the partridge, the woodcock, the snipe, the pheasant and grouse. What are the different kinds of fish? There are salt-water fish and fresh-water fish. What is fresh water? The water of lakes, ponds, rivers and streams. What are the best-known sea-fish? They are (the) cod, herring, smelt, mackerel, sole, turbot, whiting and skate. And the fresh-water (those of fresh-water)? Salmon, trout, carp, perch, and pike. Who are those who catch fish? They are fishers. With what? With lines and nets. What is eaten with meat? Vegetables. What are vegetables? They are plants that also serve for the sustenance of man. What are the principal vegetables that are cultivated in France? Potatoes, cabbages, beetroot, carrots, asparagus, beans, haricot-beans, and peas. What is a kitchen garden? It is the garden or plot of ground where vegetables are cultivated. And an orchard, what is that? It is the plot of ground in which there are fruit-trees. What are the principal fruit-trees and their fruit? The pear-tree, of which the fruit is the pear; the cherry-tree, which produces cherries; the peach-tree, on which peaches grow; the nectarine, of which the fruit has the same name as the tree; the plum-tree and the apricot-tree, which give us plums and apricots; and the apple-tree, with the fruit of which cider is made. What is the plant which is cultivated to make wine (of it)? It is the vine. What is the fruit of the vine? It is the grape.

Key to Exercise XIX.

Vous me demandez l'histoire de mon bouvreuil; la voici. Un de mes amis a une maison à la campagne. Je passe quelquefois l'hiver chez lui. Moi, j'aime la campagne en hiver; vous aimez mieux la ville, vous. Chacun son goût. Il y a deux ans j'y ai fait un séjour de plusieurs mois, et pendant que j'y étais j'ai fait la connaissance d'un bouvreuil. Il était un peu plus gros qu'un moineau. Il avait le bec épais, noir et dur. Ses petits yeux avaient une expression aimable. Je n'ai jamais vu de plumage plus beau, plus lustré que le sien. Il avait la tête noire et la poitrine presque aussi rouge que celle d'un rouge-gorge. Il avait les ailes tachetées de rouge aussi. Il avait la voix douce et je n'ai jamais entendu de sons plus moelleux et plus variés que ceux qu'il filait. Il m'égayait et me charmait. Je le soignais, je le caressais. Quand on m'apportait mon déjeuner je lui donnais le sien aussi. Je lui donnais tout ce qu'il aimait le plus: des miettes de pain, de petits morceaux de biscuit et de sucre. Il les becquetait dans ma main. Nous étions (de) bons amis, lui et moi. L'hiver était rude, mais cela ne nous inquiétait pas. Un bon feu flambait dans la cheminée. Nous avions une ample provision, moi de livres, lui de chenevis. Nous étions heureux l'un et l'autre. Nous étions contents l'un de l'autre. Pour les oiseaux une cage n'est souvent qu'une prison. La sienne n'était qu'une chambre à coucher. La porte en était toujours ouverte. Presque toute la journée il vagabondait à travers la chambre. Elle n'était pas plus à moi qu'à lui. Quelquefois il voletait autour de moi. Il sautait sur mon épaule et même sur ma tête (Il me sautait sur l'épaule et même sur la tête). Il m'ébouriffait les cheveux. Cela l'amusait et moi aussi. C'était un gai compagnon. Je n en ai jamais eu de plus gentil que celui-là. Je ne passais pas toutes mes soirées avec lui. Quand je rentrais je le trouvais endormi, la tête sous l'aile. Le bruit de mes pas l'éveillait. Il me saluait par un petit gazouillement. Le lendemain, moi, j'étais éveillé par mon petit ami. Mais la fin de mon histoire est quelque chose de bien triste. Un jour le bouvreuil trouve la croisée entre-baillée. Pendant que j'ai le dos tourné il passe vite dehors. A vingt pas de la maison il y a un gros fumier jaune et noir où une demi-douzaine de poules grattent et becquètent. Ce n'est rien de beau, mais c'est quelque chose d'intéressant pour lui. Du rebord de la fenêtre il vole sur le fumier. Mais c'est un intrus. Les poules ont l'humeur intolérante et hargneuse. La vue du bouvreuil les fâche. Elles l'entourent, le houspillent, l'attaquent. Le bruit m'attire. Je regarde par la croisée. C'est lui; c'est mon pauvre bouvreuil. J'enjambe la fenêtre; je vais au secours de mon petit compagnon. Je chasse les poules. Je le tire de leurs griffes. Il est trop tard. Mon pauvre petit compagnon est mort.

Continued

The Manufacture of Silk Hats. Body-Making. Finishing. Shaping. The Cutting and Making of Various Shapes of Caps. Straw Hats. Making Felt Hats.

HAT AND CAP MAKING

SILK HATS

The silk hat was first manufactured in France, and its introduction into England was at first conducted with great secrecy, especial care being taken to prevent anyone seeing the process except those whom the hatters had agreed to teach "the art and mystery of silk-hat making." However, at the present time the journeymen silk-hatters of this country are as skilful as any of their foreign rivals, and the English-made hat holds its own in the markets of the world.

The variety of shapes in the crown will not be dealt with, as they alter and change so often, but the various curls and shapes of the brim will occupy a prominent place.

The first article to be made is "proof," which is composed of best orange shellac (2 parts), button shellac (1 part), let down by ammonia ($\frac{1}{4}$ lb. to every 8 lb. of shellac).

The Foundation of the Hat. The foundation, or body, of the hat is made from calico of different strengths dipped in the "proof" and stretched on frames. First of all we take the brim, which, being the strongest, takes the longest to dry. After the "proof" has been thoroughly cooled, take a frame about 5 ft. by 3 ft. 6 in. along the woodwork of which are a number of nails with large heads and the points protruding on the reverse side about $1\frac{1}{2}$ in., with 5 in. between each nail. Then put the calico, No. 10 or D, in the proof and thoroughly saturate it, taking care in every instance that all parts have absorbed some.

1. FITTING THE BRIM

It is not absolutely necessary that this should be so heavily "charged" with proof, so draw it through the hand. Stretch it on the frame and prepare a stronger calico "twill." This must be charged with proof more than the previous one; in fact, it should be left as full as possible without running. Stretch it on the top of the fold already on the frame, taking care to squeeze both together with finger and thumb at every nail. Then rub with the flat hand, so that the proof of one will adhere to the fold of the other, taking care to begin at the centre and work outwards. The reason for this is to prevent any air between the two "plys," which would prevent their adhesion. As this is an important factor in the manufacture of a good sound brim, special care should be exercised. These two plys are followed by other two, put on in the same manner, the frame to be turned top to bottom after each "ply" is put on to prevent the proof from running to the bottom of the frame if kept in one position too long. Now we are ready for the drying process. Heat plays an important part in the making of the body, yet, while it should be dried quickly, it should not be scorched, for a scorched body never wears well. Therefore the best plan is to dry in a hot stove, but away from the fire that heats it. The crown is then dipped in a similar way, but only one ply is put on the frame.

The Block. The block is made from wood and shaped according to the fashion; some "bell" more than others, whilst some are called taper or straight crowns. The block is made in five pieces, the two largest being for front and back of hat, whilst one is placed in position for each side and the whole is fitted tightly in the hat by a centre piece, graduating from tip to head part.

Take a strip of calico about 8 in. deep and measure twice across the length of the block and once across the width; cut, and fasten the ends together by laying one about $\frac{1}{4}$ in. or $\frac{5}{16}$ in. over the other and running a warm iron over them. Do not have the iron very hot or it will harden the seam. Place the front and back pieces of the block inside the foundation, allowing $\frac{3}{8}$ in. over tip; put in the two side pieces. It will be seen that the "foundation" appears too small, but a gradual warming will allow both the sides and centre piece to be put in. Round two sides of the centre piece put a piece of brim stuff to make the hat a little larger. This "packing" is to allow for a shell which is used at a later stage.

Stretching the Tip. For the next calico required it is necessary to dip a piece in spirit proof, which is best orange shellac dissolved in wood naphtha and called varnish. Having dipped the calico in the varnish and dried

it, cut it into strips of about ½ in. and place ¼ in. on the side crown from the tip, fasten with a warm iron and then iron the other ¼ in. on the tip of the block. Cut level all round. Take another piece of foundation and fasten on the edge of the tip, stretching by warming it, then cut round with scissors. It is necessary to *stretch* the tip, for, if allowed to be fastened slack, it will sink, and to prevent that the tip is stretched to its utmost capacity by warming it and then fastening it to the edges left over from the foundation.

A large mug or tin containing waterproof placed on the back of the bench is necessary, also a brush after the same pattern as a large paint-brush. With the brush apply a coat of proof to the tip and stretch a piece of plain calico across as in the manner described before, and again "proof" it, to make it adhere to the previous portion of the tip and form one solid substance. Take another piece of the calico, which has been dipped in spirit, about 1¼ in. wide, and iron it round the tip in the same manner as the previous one, placing about ¾ in. on the side crown and the rest on the tip.

Fixing the Brim. Take a brim, size 13 in. by 12 in., place it flat on the bench, and arrange the head part of the block in the centre and mark with a knife—or anything with a point—round by the block. Do not cut, but simply mark. With a pair of scissors cut out the centre, allowing about ½ in. inside the mark. A wooden frame, called a sunk frame, because the wood is hollowed out to allow the block to fit inside, is now required, the right depth being got by placing pieces of wood underneath the block and allowing ⅛ in. for the thickness of the brim. With a hot iron thoroughly soften the portion inside the mark already made, and then smartly pull over the tip of the block as far as possible. With an iron dummy press it as close to the frame as it can be got, making sure to have some portion of the brim up the side crown of the hat, which must be ironed together a little portion at a time, and followed immediately by the dummy being pressed on the portion ironed. Sides should be done first, then back and front [1]. With a knife cut or pare away a portion of the brim which now adheres to the side crown, taking care not to cut the other portion of the brim, but "paring" it gradually thinner towards the top so that it will not appear thick and bulky.

Take the centre of brim, already cut out, and split the four folds apart; cut two pieces, 2 in. by 1 in., from one of them and iron one on front and the other on the back, ⅝ in. on brim and ⅜ in. on side crown. Cover that piece with a larger one ironed on in the same manner. Iron a spirit "robbin" round the band of the hat, the same width as the previous one, to fasten the brim and side crown more firmly. See the hat is the exact depth; take it out of frame, and cut away the corners of the brim.

With the brush apply a coat of proof to the side crown, taking care not to miss any portion of it; then take a piece of fine muslin about 8 in. wide, beginning at the centre of side with the body seam on the right hand, and pull it round whilst the proof is wet so that the calico will adhere to it. When covered, cut off, take up the end first laid and lay the left side of seam over right; with scissors cut the calico over the tip with the exception of ¼ in., which must be ironed over. The remaining portion of the calico must be put on the tip—after it has been proofed—in the same manner as the previous one; then carefully cut off all corners and apply another coat of proof to all parts of the body, the brim included, and place in stove to dry. Again "proof" it whilst warm; let it cool and then pull block out. Another coat of proof must now be applied, and allowed to dry without the block being in the body.

The Ironing Process. It is now ready for the ironing or smoothing process, for up to the present it presents a rough appearance. First cut away closely with a knife the foundation from underneath the brim; place inside a shell or felt body (self colour), making sure that it fits the tip closely, and put in the back and front pieces of the block. Next fit the side and centre pieces, neither of which will go into the bottom at first, but after an application of gum, powdered in a rag, and a slight application of vegetable wax, the front part can be ironed over until quite smooth with a clean hot iron, followed immediately with a cool iron dummy to set the heated part. Knock the side pieces a little further down and repeat the operation to the back of the body, when the block will easily go in with the exception of the packing pieces, which are not needed now that the shell is in the body. The remaining portions of the body are now ironed, including tip, making sure that all the seams are pressed down, until it has a smooth, level surface; then let it cool, tip downwards.

Next get a brim frame which differs from the one previously mentioned, as it has no portion cut away for block, but has two pegs fitted in on which is placed a brow the size of the hat, and a piece of felt covering the whole frame. Iron the underneath of the brim on a plate fixed in the bench and shaped to the oval of the hat; then immediately place it on the frame, iron it well, and again repeat the operation on the underneath, following it with the cool iron dummy, both on the underneath and also on the top side of brim when on the frame. Iron first one side then the other, followed in order by back and front, making four distinct ironings for the brim. When well ironed it is ready to be varnished before being handed over to the finisher, whose work it is to place the silk on the body.

Finishing. The tools required for the finishing process are these: Irons (1 pair), dummies, 1 concave iron, 1 flat iron, 1 concave wood, 1 flat wood, wire cards (1 tip, 1 side), brushes (1 hard, 1 soft), velures (1 rough, 1 velvet), scissors (1 seam, 1 crooked, 1 ordinary), sponge, stirrup, woollen patch, half block, tip block, brim frame.

Finishing is the art of sticking and retaining the bright colour of the plush. The body, after it has left the bodymaker, receives two thin coats of varnish. The plush is stuck to the body

by means of cold water sponged on the plush, then a warm iron being lightly passed over, and thus a steam is created. This steam enables the plush to stick to the body. The finisher fits the cover on the body the reverse side up; then he measures and marks with chalk the exact line where the seam must be cut. The selvedge side will be on the right-hand side. Mark ½ in. from selvedge, then pass left-hand side over, and mark to correspond. Take cover off and apply a coat of proof on back of plush 1 in. wide over where the seam has to be cut. This stiffens the plush, and will stop it from threading.

When the proof is dry, take cover in left hand and brush back the nap on the top of the seam; place cover on bench, and apply water on the plush; pass iron over and card back the nap. When well carded, back iron till dry. Then cut with scissors down chalk line and cut selvedge side. Take the plush for brim, damp on the back side, and pull out with fingers wider and shorter. This takes the stiffness out of the plush, and enables it to fall into the band of the hat easily. When dry, pass round outer edge of brim, and stick with cool iron.

2. CURLING THE BRIM

Now get brim frame on patch or felt, as used in brimming body, and pull into position the plush with stirrup, care being taken to pull out all the pleats. Then sponge, brush the nap straight, and pass iron over. The brim is usually pulled in at four separate times, first front and back, then sides; when stuck, cut with crooked scissors, care being taken to cut the brim plush ⅛ in. up the side crown. Now place body on tip block and fit the cover; pass sponge over, and stick top of seam first; when seam has been securely fixed pass tip card over the stitching.

Sticking the Cover. Stick the tip in position, care being exercised to have all the stitching on tip; do not allow it to drop on the side crown. The nap will then be across the tip from left to right. This must now be carded round to the centre. Damp the plush with sponge, pass warm iron over, and card the nap round while the steam is rising. Again apply water, iron, and card, and the nap will now be in position round the tip.

3. HALF-BLOCKING

Place hat on half block (which must be covered with three or four layers of felt), stick the back of hat first, working towards the seam. See that the right-hand side of seam is well stuck.

Bring the seam together, and stick about 1 in. at a time. Brush the nap back to its right position over the seam, and stick remainder of hat; brush well, apply a coat of cold water, and card the nap straight. Water the tip, and bring nap well round to the centre. When dry, brush the glaze, and the plush will now have a dull appearance. For half-blocking, use a warm iron and go round the hat twice; the first time will bring the colour back, and the second time get the hat round [3]. When half blocked place a paper cap on side crown. To cover the underside with merino, apply a coat of varnish, and brush the merino on while wet. Cut merino ½ in. from band, and stick it down side crown; run iron on the top side on brim frame, and the hat is finished.

There are four points to be remembered: (1) when the hat has been warmed with iron, dummy till cold; (2) plush to be well stuck on body; (3) seam and stitching to be pressed well down; (4) the bright colour.

Shaping. The hat is now ready for the shaper, whose duty it is to make a curl and set the hat to its proper shape. This branch has been justly called the "artistic branch," for the appearance of the hat depends to a great extent upon the shaper. A variety of curls and sets are dealt with by the shaper, which, more or less, lends to the attractiveness of the hat. Space, however, forbids us to deal with more than the principal shapes, for the others are but a distinguishing feature, while the workmanship is on similar lines, except in detail as to the size, etc., of curl or set. We will deal with a ½-in. roll, which is the common size of a curl.

First place the hat tip to plank, with the front facing you; then get the centre by placing finger and marking plush on top side of brim; turn the hat round, and perform the same operation with the back. Then place the hat brim to plank, with the centre marks exactly level from left to right. Warm the brim with the iron until it is just bendable, run flat plough over the warm part; then, with a piece of plush between thumb and first finger of left hand, pinch the edge of brim upwards, beginning about ½ in. from the mark on right hand, and finishing about the same distance from the left-hand mark.

The machine or roll brass is now used by running it along the brim and gradually turning it over to the required size [2]. Great care must be exercised in order to ensure a very even and symmetrical curl, and the brass curler must be kept flat along the plank, so that the curl can fit perfectly in the groove. An even and perfect curl is largest in the centre, tapering smaller at the shoulders. It is easy to understand that if the same pressure is exerted all along the brim, the result will be a curl one size from beginning to end; but that is not what is required. Therefore, a gradual pressure and release of same, whilst the brass is in motion, obviates

that, and makes the shoulders or ends considerably smaller than the centre. Having made the curl the required size, the brass or machine must be removed, and under the curl is placed a "rope" or "roll pad," whilst the brim is warm and pressed on the "rope" with a grooved plough. This "rope" or pad is made from calico or tissue paper, the former preferred, as it lasts considerably longer. The curl is now really shaped, but to prevent its losing its rotundity it must be ironed along the top edge, which will produce a shiny surface on the merino. After sufficient ironing, the grooved plough again comes into use in pressing and keeping it to the shape of the ropes. When the rope is removed, a perfectly formed curl is the result, but to ease the setting of the hat it is necessary and expedient to *round* the brim. To do this successfully it is imperative that great care should be exercised.

Get a piece of swansdown, about 12 in. by 9 in., and place it on the merino (with tip of crown to plank); then take a sponge and damp about 1 in. wide from the curl; rub over with the iron a few times, when the steam will have sufficiently warmed the brim to make it pliable. With first finger well under curl and thumb on the merino side of brim, pull round, beginning at the farthest point from you. As in curling, so in rounding, the greatest rounding should be in centre, tapering to each end. This will leave the front and back of brim perfectly flat, and, after curling both sides, the *fronts* can be put in. Place hat on tip, with the curls parallel to you, then gently rub the iron along the inch or so of brim that has not yet been touched, until it is bendable; pinch it as in curling, joining the two curls together, get the *front groove*, and work it along until the front is level. Care must be taken to see that the ends of the curls are evenly joined together by the front, and after front and back have been put in the hat is curled, but not quite finished, for you will observe that the edges of the curls are rough.

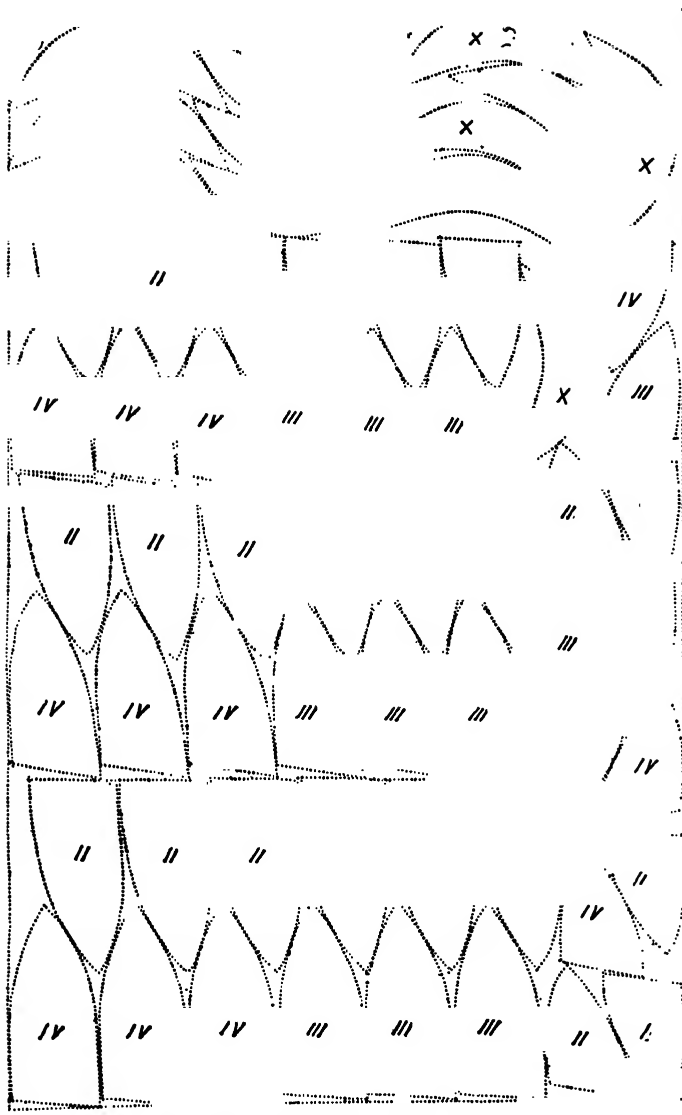
4. LASHING THE LEATHER

Paring the Curl. To put a perfect finish on the curl it must be pared or chipped. First get a knife—one made from an old razor is best as it lasts longer—which must be shaped and cut out at the front and back, leaving it very small and level. With a paring machine the sides must be cut to make the edges smooth and both curls equal in size. It will be seen that the plush and merino make the curl look ragged and very untidy, but the knife run under or along the edge of the curl will remove the former, whilst the latter may be cleared away by the use of scissors. A piece of fine sandpaper run along the edge of the curl will mend it in appearance. The hat is now placed on a "horse," an arrangement made of wood hollowed out at the top to allow the hat to fit steady, with a "duffer" in it. A duffer is placed in the hat to prevent the heat of the fire from *drawing* the crown of the hat out of shape. It is made from paper or felt and fits close to the head part of the hat. When the hat is warm enough to be bendable, it is ready to be set. Care must be taken not to have it too warm, or it will cockle the brim, making it very uneven.

The shaper places the tip on the plank and begins to make the hat the shape required. When the sides are set to the desired width it will be seen that the back and front look hollow and unlevel, especially in the band which is near the head part. To put it level a cloth has to be placed across the front, water it with a sponge, and then iron it until it is again workable; turn it over, and with a flat plough work the top side of the brim whilst the underneath is placed on a "cheese" or "half frame." It must then be worked with thumb and finger until it is straight, the shoulders are level, and the curl is in perfect symmetry with the brim. It is now ready for the trimmer.

Trimming. The *trimmer* receives the hat after being shaped, along with the following trimmings: Band and binding, tip paper, side paper, silk tip, silk side, leather, tassel, and sticker. First find the centre of brim at back of hat, then measure binding round the edge, and, after cutting it to the size, sew the ends very neatly before sewing it on the brim, the seam to be at back of hat. The binding will then be on the top side of brim with the stitches going through. It must be rubbed on the underneath with a bobbin, to prevent the stitches showing through the binding. Now turn the binding over curl, and sew, or "whip" it to the merino underneath. Then tie the band round the crown of hat, placing bow on left side.

Take the tip paper, which is very stiff, place it on the tip on hat, and make an impression round the edge with thumb and finger, which, after cutting, gives the size required, and is ready for the silk tip to be stitched on. The silk side is now sewn round the edge of the tip and the ends "run up" together, the whole forming the lining, but before putting it in the hat the side paper is fixed and made firm with a little paste; this prevents the colour of the body from showing through the silk side. After fixing the lining in, sew it round the top of the paper, which causes it to "bell," through its being cut on the bias, or cross. The leather is to be measured round the inside of the hat and the ends cut so that they will just meet, both being cut on the slant, so that a little more will be cut off the bottom than top. Place the edges of leather together, and with a sticker (a gummed piece of paper) fasten them; also make the tassel into a "bow" and stitch it to the back of the leather. Now place leather in hat, putting the seams of binding and leather in the centre of the back of hat. Get a thin cord (top cord) and fasten it on top of leather with the stitches used for sewing the leather to merino [4]. It prevents the top of the leather from showing


5. CAP-MAKING: ARRANGING MATERIAL ON

person who has a knowledge of producing other articles of wearing apparel.

As a home industry, however, cap-making has largely died out. It has been killed by machinery, skilled factory organisation, and subdivision of labour. All these things tended to make the cloth cap wonderfully cheap, but since the introduction of a much higher class for motoring purposes, and of a greater degree of artistic design in those now worn, prices have risen to so great an extent that a really well-made cloth cap is rated at a price practically equal to that of the best kind of bowler or the cheaper make of silk hat. Still, there appears no reason why cap-making should not be developed as a home industry. It is comparatively simple work.

The ordinary kind of cap is produced from eight three-cornered pieces which, when laid out flat, would form the segments of a circle.

In the factories these pieces are cut from cardboard discs representing the different sizes. Thus, the circumference of the disc for size 6¾ would be about 25 in. The actual circumference for a size of 6¾ is 22 in., but the extra inches are allowed for the seams. By careful cutting a yard of cloth 54 in. wide would make a dozen golf caps of average sizes.

Getting the "Lay." The usual practice of the cap manufacturer is to purchase a number of pieces of tweed made in the large home-spun check patterns which are now the favourite designs. When these are delivered at his factory the first process is to get what is called "the lay"; that is, to arrange the cloth so that the caps can be made with the least possible waste of material, due regard being paid to the necessity of matching the pattern when the pieces come to be put together.

When this has been done, a pattern is cut out of several thicknesses of cloth by means of a band knife, which will cut through a hundred layers of the material as easily as one. The parts are then ready for the machinists, who stitch the several pieces together, after which the partly made-up cap is passed on to the finishers, who put in the linings—which are cut by the same process—cover the peaks, put strapping on the seams, and complete the work.

In the making of the caps there are four distinct processes: cutting, machining or sewing,

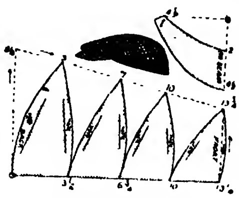
through the stitches and gives it a more finished appearance.

The hat is now ready to be returned to the shaper, who, with his brim iron, irons the brim and brushes it until the plush presents a smooth and finished appearance. Run down the band with a band peg or thin piece of wood, strip the paper cap, iron the crown, and follow with a velvet velure. Put on the white cap, and the hat is completed.

CAP-MAKING

To-day, cap-making gives employment to thousands of hands, has special factories and machinery, and large sums of money are invested in the industry. But there is no reason why caps should not be made by any

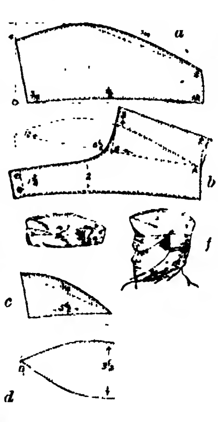
pressing and finishing. The workers become exceptionally expert in their own particular departments. The cutter can lay out his cloth so that there is no waste, the machinist can join the pieces together with marvellous quickness on the electric power sewing machine, the pressers open the seams and mould the shape on blocks, and the finishers can complete the article with wonderful rapidity. With the exception of the cutters, the hands are women workers, and one expert cutter can easily keep fifty or sixty machinists busy.



6. CLOTH CAP

The term "finishing" includes the process of sewing in the linings and other hand work, and sometimes the finisher does the pressing and blocking. When the cap leaves the hands of the machinist it looks like a cloth bag, but by careful manipulation upon a wooden block, and by the aid of a heavy iron like a tailor's goose, the seams are pressed down and the cloth shaped ready to wear. On an average a cap passes through nine processes and through the hands of as many workers before it is complete.

The rapid growth of the trade would, of course, have been impossible without the sewing machine and the band knife, but especially the first named. A cap factory, in its way, shows some of the best points of modern industrial organisation. The different processes dovetail into each other, and there is no waste of time or energy. The result is that a good, useful cap can be made to sell at a shilling, which fifteen or twenty years ago would have cost five times as much. The employes earn a fair living wage on account of the large quantity they can produce with the aid of machinery, skilful organisation, and careful subdivision of labour. The reason that the cap trade has settled down in London and Leeds is that it is an adjunct to the ready-made clothing trade. The class of labour required is very similar, and in both London and Leeds there is an unlimited supply of skilled machinists. When work is slack in the clothing factories they can work in the cap factories, and vice versâ.



7. THE 'GLENGARRY' CAP

Sizes. It is worthy of note that north of the Humber the caps in demand are of a larger size than in any other parts of the country. The average size throughout Lancashire and Yorkshire and the Northern counties is $6\frac{7}{8}$; in the South it is $6\frac{3}{4}$. The sizes of the caps start at 5 and go up to $7\frac{1}{2}$. After that they are called "out sizes"; $7\frac{1}{4}$ is considered large, $7\frac{3}{8}$ is seldom asked for, whilst $7\frac{1}{2}$ is thought abnormal. A man with a head above that size would have to have his caps specially made. The first size (5) fits a head of 18 in. in circumference, and each additional size means an average increase of $\frac{5}{16}$ in. The medium size ($6\frac{3}{4}$) fits a head circumference of 21 in. A size is obtained by taking the length and breadth of the head, adding them together, and dividing by two. The golf cap is the favourite style for men's wear, but a great variety of shapes are produced, and the different patterns of a large manufacturer will number a couple of hundred.

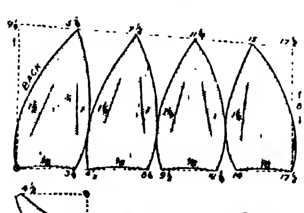
The variety is caused by the different fashions in women's and children's caps, and a great demand has sprung up recently for women's golf and motoring caps. The characteristic features are, however, retained in the various styles, the chief differences being in respect to size, shape of peak, and other details.

The accompanying diagrams show the method of cutting two of the standard shapes, and also the service cap known as the "Glengarry." Size 7 is taken as a model, and as the figures correspond to those of the ordinary inch tape, modifications both as regards size and style can easily be introduced.

The Golf Cap. The golf cap is cut in ten pieces, eight of which are sections of the upper part of the cap, and the remaining two form the peak.

The accompanying diagram [8] is a reduced model of one of the best shapes of a leading maker. The size can be varied by adding a little to, or taking a little from, the various seams; the inside portion of the peak is cut of the same shape, but rather smaller than the lower diagram. The various parts should be taken from the cloth in much the same way as they are arranged on the diagram, and should be cut exactly on the line, as provision is made for $\frac{1}{4}$ in. seams at all parts.

Now baste the various parts together and sew the seams by machine, making the seams $\frac{1}{4}$ in. wide, and in doing this, care must be taken to get a neat finish at the point where all the sections meet. In order to do this, the best plan is to make up the two sides first, and then seam these together from front to back. Prior to this, however, it will be advantageous to press the seams. Cap-makers have proper blocks for this, the shape varying with each style of cap; much may be done by turning a sleeve-board on its side and using the rounded end. The seams being sewn and pressed open, the peak is made up and stitched, and in order to ensure its being put on in the centre, fold the peak over and make a notch, putting this to the centre seam in front. The peak is lined through with heavy canvas.



8. GOLF CAP

The edge of the cap is now turned in, and it is ready for the lining, which is done in

various ways: (1) A lining of silk the same shape as the outside, which is felled round the edges. (2) A leather headband round the bottom, and a silk head lining in the crown after the style of a hat. (3) A leather band and the seams covered with galloon after the manner shown in the sketch, the galloon being stitched on so as to cover the seams and make a neat and light finish.

The top of the cap where all the seams meet is usually covered with a small button made of the same material.

The front is provided with a hook and loop or a glove fastener to make it pouch over in front, and sometimes ventilators are put in the crown, after the style shown in the sketch.

There is room for a good deal of skill in the finish of caps, and this has more to do with the pressing than any other part; the superior shape imparted to those made by high-class firms is due to the extra facilities they have in the way of blocks and so on for the pressing purposes.

We also give another style of cloth cap, with a flatter front and not so full a crown [6]. This is a style of cap very popular in the North of England. Thousands of these are made up in Leeds, where they are produced very cheaply in the way previously described. The lay here given [5] was photographically reduced from one in use at one of the largest factories. It will be seen that no material is wasted, and in order to avoid confusion the various parts are marked in numbers. These lays are prepared in buckram and are perforated; they are then placed on the cloth from which the caps are to be cut, and a pad containing powdered chalk is passed over it, and the outline is marked.

The Glengarry Cap. By way of making this article complete we give diagrams showing how to cut a Glengarry cap with part to turn down over the ears and fasten under the chin [7]. This diagram has no provision made for seams, and the size head it will fit is 7. Figures *a* and *b* represent the side, *c* the peak, and *d* the crown. Two each of these parts are required for the cap, together with peak, lining, and lining for *b*. The peak is cut on the crease. The process of making is much the same as already described, though the peak would be finished in softer style.

We give illustrations of this cap folded up, and also in wear with the ear laps brought down and fastened under the chin [7*e* and 7*f*].

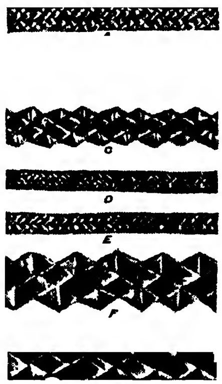
The following table gives the ordinary range of sizes, together with the head measurements to which these sizes correspond:

18½	18⅞	19¼	19⅝	20	20¼	20¾	21¼	21⅝	22	22⅜	22¾	23¼	23⅝	24	24⅜
5⅞	6	6⅛	6¼	6⅜	6½	6⅝	6¾	6⅞	7	7⅛	7¼	7⅜	7½	7⅝	7¾

STRAW HATS

The making of straw hats, especially for women's wear, is one which can be easily carried on at home, as no expensive appliances are needed.

Straw hats are roughly divided into two classes, "block" and "shape" styles. The first have hard crowns and brims, and the shaped styles are usually soft and flexible. The "shape" styles are, as a rule, confined to the various sailor types, and to make them a block is necessary. The straw plait is sewn into a circular mat, and then placed over the block, and by means of a hot iron it is manipulated into the same shape as the block. This forms the crown, and the rim is blocked and pressed in the same fashion. The rim and crown are then sewn together, and the hat is ready to be trimmed and lined.



9. STRAW PLAITS
a. Pedal white *b*. Canton white *c*. Fine rustic white *d*. Tuscan white *e*. Fine pedal white *f*. Coarse rustic white *g*. Coarse rustic black and white

As stated, blocked hats are for the most part factory made, but the shaped styles for women's wear can be easily made at home. The first thing necessary is to get the skeleton, which is made of wire. This can be bought ready-made, or it can be fashioned to suit the individual taste. A plain hat of the sailor pattern can be made with three circles joined together by oblong pieces, all of wire. Upon this skeleton the straw plait is sewn, and when the hat is complete the wires can be removed, or if it is desired they can remain in the hat to enable it to keep its shape. There is a great variety of colours and styles, from the fine and narrow English and French plaits, and what are described as the rustic Japanese, which are the largest and coarsest kinds [9]. It will easily be seen that a hat can be made of a broad plait much more quickly than from a narrow one, and for that reason the broad plaits are much more in favour. The plaits are sold in bundles 12 yd. long, which is sufficient to make a large hat. The price per piece, or bundle, is from 6d. to 6s., according to style and quality. The wire skeleton costs only a few pence [see also MILLINERY, page 2237].

For men's and boys' straw hats the principal shapes are the "Boater," which has a flat top, and a flat brim of varying degrees of width, and is made from both the fine and coarse kinds of plait; the "Trilby," or Alpine style, with indented crown, for which the fine Tuscan or pedal straw is used, and the "Panama" shape, for which the finest plaits are also required. The real Panama is not made from straw, but from a long grass grown in tropical and subtropical countries, and the hat itself is plaited from the grass fibres, considerable time being occupied in the process.

The scale of sizes given for cloth caps will be equally serviceable for the ordinary shapes of straw hats.

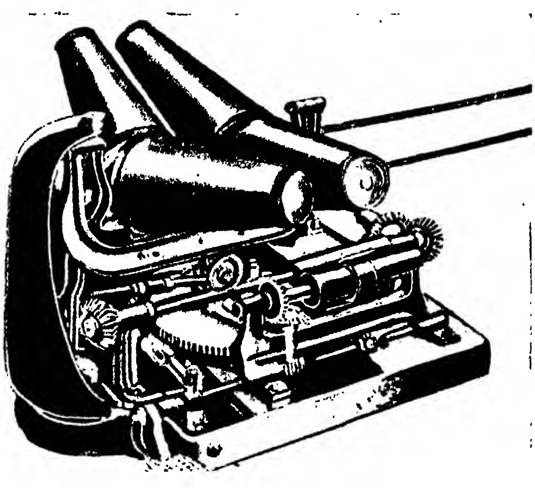
FELT HATS

Hundreds of machines have been invented for the manufacture of felt hats, the end in view being to obtain the best machine possible for converting the wool into a good felt hat by the aid of heat, moisture, and friction.

As nearly the whole process of their manufacture is by machinery, we shall here consider the materials used and quantities required

Cleansing the Wool. Felt hats are made from the fur of the rabbit, beaver, nutria, etc., After obtaining the wool, it is necessary to give it a thorough washing to free it from the natural yolk or animal grease, or any foreign substance the wool contains, before the felting operation can be begun. It is afterwards passed through a "willow" for the purpose of opening it out.

The carbonising process may be done in a variety of ways by using a dilute acid, the object in view being to destroy all the vegetable matter which clings to the wool, for the presence of any such matter has a tendency to disfigure the appearance of the hats when finished. The wool is then passed through a carding engine. with its several rollers, wire combs and cylinders, which opens it out to an almost cobweb-like texture. It is next taken to the forming card, in front of which is placed the "forming machine" [10], and, as the wool is stripped by the comb from the doffer, it is taken up by the forming cone, which revolves upon four rolling cones. This machine has an oscillating motion from lett to right, and vice versa.



10. THE FORMING MACHINE

The "Forming" Process. By this means the wool coming from the doffer is crossed as it is received upon the double cone. This crossing of the wool upon the cone greatly facilitates the felting process. The reader will understand why this is if he refer to the articles on fibres on page 1159, and notice the structure of the wool fibre, the serrated ends, and the scales overlapping each other, which become interlocked in the operation of felting. When sufficient wool has been delivered upon the double cone, it is cut in two by the insertion of a pair of light shears in a recess which runs round the larger diameter. The forming is conducted by women, whose sensitiveness of touch enables them to determine when a sufficient weight of wool has been delivered on the cone. After leaving the forming department, they are passed on to the hardener. There are two different methods of doing this, called "cup and cone" and "flat" hardening. The "cup and cone" hardener is a machine possessing a slow rotary movement. The wool "forms" are placed on a perforated copper cone, heated by steam; between each form is placed a cone-shaped cloth, to prevent the forms adhering to each other; the cup is then placed upon the cone, and its quick reciprocating movement gives the first operation of felting. The "flat" hardener performs precisely the same function as the hardener; but here the felting is performed by friction between two plates.

"Planking." Planking—the next process—is the second operation in felting; the "forms" are the same length and width as when they left the former—14 in, by 21 in.—but the soft, wool-like appearance they possess has been changed to a cloth-like texture by the first felting process—that of hardening. In the planking department, "batteries" are arranged to accommodate from four to six men, the planks being about 30 in. by 40 in., in the centre of which is a large kettle filled with water, and heated by steam or fire to boiling-point. Then the planker takes three or four of the forms, rolls them in a cloth, dips them in the boiling water, and rolls them on the plank to assist the shrinking operation, afterwards taking them from the cloth, to change their position before again repeating the same operation, to keep them in shape and prevent adhesion to each other. They are then taken to the "settler," who rolls the forms in a cloth and places them between the four rollers of the "settling" machine, the rings of which run in a transverse direction, the rings on the front rollers running from right to left, those on the back ones vice versa.

The hat "forms" are felted up by this machine 4 in. or more if required. They are then placed in the "bumpers," which machine contains a pair of large blocks of oak, in the pit of which you place the hat "forms" or "hoods," where they are pounded and milled up to the required size. The finishing touches in this department, so far as machinery is concerned, are given on the "stumping" machine, which is somewhat like the "settling" machine in construction.

They are now given the finishing touches by hand at the battery, after which they are put into hot water and washed to free them from the sulphuric acid used in planking to assist the process of felting. Now they are placed on a wooden cone-shaped block to free them from the marks that have been caused by doubling them

in planking. They are then placed in the stove to dry. We have now reduced the hat from 14 in. by 21 in. to 9¾ in. by 15¾ in. The best bodies are produced by the subtlest of all machines—the human hand. No machine yet contrived for body-making can equal the fine machinery of the human finger.

Stiffening the Shape. The next process is that of "proofing," or "stiffening," so that the hat will retain its shape, and become impervious to rain. For this purpose a double-jacketed pan is required, to dissolve the necessary ingredients, heated by steam, in which which place 14 lb. of resin, 6½ lb. of borax, 60 lb. of button shellac, and 20 qt. of water. Dissolve the resin and borax in the water before entering the shellac, and after the whole mass has dissolved shut off the steam, and allow it to cool down a little; then add water until it is the strength required for the purpose of stiffening the hats. Two large mugs, or troughs, are now required, to be filled with proof of different strengths—the stronger for the brims, and the weaker for the crowns.

The hat bodies are still cone-shaped, and, to start proofing, take hold of the tip or crown with the left hand, immerse about 4 in. in the strongest proof, place it on the bench, and with a piece of wood about 6 in. square held in the right hand draw off the superfluous proof, then croze it, and repeat the operation. Now allow it to set while a few more brims are done. The hats are then dipped bodily into the weaker solution for the crowns, the "dry-board" being used to draw off the excess of proof. Then allow them to drain and set, after which they are placed in an iron steam-chest, containing cone-shaped stands. Put a dozen hats on each stand, cover with a cloth, close the chest, and turn on the steam, which must not be below 30 lb. pressure to the square inch. Allow them to remain 40 minutes, then shut off steam, and spread bodies to cool. Now put them in a stove heated to 120° F., where they remain three hours. Again steam for another 40 minutes at 30 lb. pressure to drive the proof to the interior of the body, so that the surface of the hat will be free from all foreign matter. After taking them from the steam-chest, allow them to cool. Take a stiff brush and brush the hats well, inside and out. Up to this time the hat body is yet of a conical shape; forming, hardening, planking, and proofing have followed each other in turn.

The hat is now taken to the "blocker," and by him the cone-shaped body is pulled out round the edge to develop the brim, and the upper part is widened out to form the tip and side crown.

Next fill a large tub with water; bring it to the boiling-point; then dissolve 6 oz. bichromate of potassium and 6 oz. of copper sulphate. After dissolving these in boiling water, put in 15 dozen hat bodies, keeping them on the move for 30 minutes, afterwards passing them through clean water. The process described is termed "mordanting," which prepares the hat to receive the necessary colouring matter. By the time "mordanting" is finished the vat, or dye-kettle, should be ready to receive the hats. Take 36 lb. logwood, place it in a coarse bag, swing it in the dye-kettle, and allow it to boil until the dyeing material is extracted from it; then take it out and put into the vat 1½ lb. verdigris and 1½ lb. iron sulphate. This may be improved by the addition of 2 lb. indigo extract. See that all the materials are dissolved before putting in the hats. After putting in the goods, keep the solution near the boiling-point for 90 minutes; by that time the hats should be of a good black. Then take them out of the vat, providing the necessary depth of colour has been got, and place them in a tub of cold water, and allow them to remain some time before washing them in warm water.

The hat is now returned to the blocker—a man working at a battery similar to that described in "planking"—who is provided with wooden blocks, the size and shape the hats are required. He softens the body in boiling water, then pulls it on the block and slips a cord over it to keep in position the part intended for the crown. He then softens the brim part, takes hold of the edge between fingers and thumb, working round the hat, and following with left hand flat on the brim until it is the required shape. He then dips it in cold water, takes it off the block, and allows it to drain before placing it in the stove to dry. When dry, brush it well with a stiff brush. The hats are now taken to the "presser," a man provided with iron-moulds or dishes. He places the correct size and shape in a hydraulic press, puts the hat in a steam or gas oven to soften, then places it in the "dish," closes the press, and turns on the pressure of 400 lb. to the square inch. The presses are provided with indiarubber bags containing the pressure, so that it may be evenly distributed over the whole surface of the hat.

The Finishing Process. The "finisher" then takes the hat in hand, and on a quickly revolving lathe smoothes its surface with glass-paper, afterwards polishing with tallow, dissolved by a gas heater and applied with a velure.

The rough edge is then cut from the brim by the rounding machine. Up to this time the hat brim is perfectly flat, but is now taken in hand by the curler, and placed on a steam baker, so that the brim only is softened, then put on a "spit" frame, which is placed in the hydraulic curling machine. After closing, the pressure is turned on from the accumulator, entering an indiarubber bag, by which it is distributed over the surface of the brim at the rate of 400 lb. to the square inch. The frames are made in all the shapes and sizes required, and, being made in sections, they can be taken from the brim without altering the shape or breaking the curl. A hot iron is run over the edge so that it will retain its shape; then cut the rough edges from the curl until it attains its proper dimensions.

It is next sent to the "trimming" department, where the brim is wired, the banding tied in a bow and fastened to the band of the hat, the binding sewn round the curl, and the leather and lining stitched and fastened in their respective positions by women, after which they are velured.

The Manufacture of Gunpowder, Nitro-glycerin, Dynamite, Blasting Gelatin, Cordite, Ballistite, Guncotton, and "T.N.T."

MANUFACTURING EXPLOSIVES

SINCE its inception until the present day the manufacture of explosives has been associated with the study of chemistry. Whoever may have been the genius that first applied the fireballs* of the ancients to the propulsion of projectiles, there can be little, if any, doubt that these early experimenters were among the fore-runners of the modern chemist —the al-chemists. No definite date can be given for the invention of gunpowder, but the first references to its use as a propelling agent date from about the middle of the fourteenth century. From that time onward it spread throughout Europe with great rapidity, as the numerous references to it in early European literature show. Gunpowder at the beginning of the nineteenth century was essentially the same as when first invented. A few slight alterations in the proportions of the ingredients and a little more care in their purification covers the improvement effected. Inventive ingenuity seems to have turned in the direction of firearms, satisfied that the propelling agent was more than sufficient for the work it had to do.

It was not until the middle of the nineteenth century that the series of discoveries was made which revolutionised the explosives industry. In 1845 Schönbein showed that cotton could be rendered explosive by treatment with nitric acid, and experiments by numerous other chemists soon reduced the discovery to a practical basis. The invention of nitro-cotton was followed in 1846 by the discovery of nitro-glycerin by the Italian chemist Sobrero, and Alfred Nobel, whose name is inseparably associated with high explosives, succeeded in overcoming the difficulties connected with the application of it to practical purposes.

The two essential discoveries on which the whole science of high explosives is founded are those of nitro-cotton and nitro-glycerin. The great majority of the explosives at present on the market under an infinity of names are mixtures in which the principal constituent is one or other of these substances.

Gunpowder. Black powder differs from nitro-cotton or nitro-glycerin in being a mechanical mixture, not a chemical compound. Its ingredients are simply intimately mixed together and are quite inert towards one another until the application of heat causes them to combine chemically, with formation of a mixture of gaseous compounds. It is this rapid chemical action or combustion which, owing to the great expansion due to the formation of gases, causes the explosion. The ingredients—sulphur, saltpetre, and charcoal—are mixed in the proportions which give fairly complete combustion, and, consequently, leave a very small amount of residue. Sulphur and charcoal are both combustible bodies, requiring only a sufficiency of oxygen with which to combine to convert them into gaseous compounds—the oxides of sulphur and carbon. Saltpetre, or potassium nitrate, is a salt rich in oxygen. Under the application of heat the oxygen in the saltpetre is transferred to the sulphur and carbon, with formation of gases. At the same time nitrogen, also a gaseous body, is liberated from the saltpetre, and other complicated changes take place which it is not necessary to detail here.

Saltpetre. Saltpetre is a natural product, found as a crust on the surface of the land in various parts of the world, notably in Bengal. The crude saltpetre is collected and its solution purified by crystallisation—that is, it is dissolved in water, freed from dirt and other insoluble matter, and evaporated by heat, so that the salt crystallises from the concentrated liquor in a purified form. The Government factory at Waltham Abbey, which may be used as a type of a modern explosives factory, refines its saltpetre as follows. The vats in which the crude salt is dissolved are fitted with a perforated false bottom, through which solid impurities settle out. Heat is applied, and when the solution boils it is skimmed, and the false bottom, containing the dirt, is withdrawn. When all the scum has been removed, the solution is run through cloth filters into shallow pans, where the crystals separate. During crystallisation the liquor is kept in motion so that the crystals may be small. As they form they are withdrawn from the solution and drained. The crystals are then washed several times with water. The mother-liquors and wash-waters are, of course, worked up with subsequent batches of crude salt.

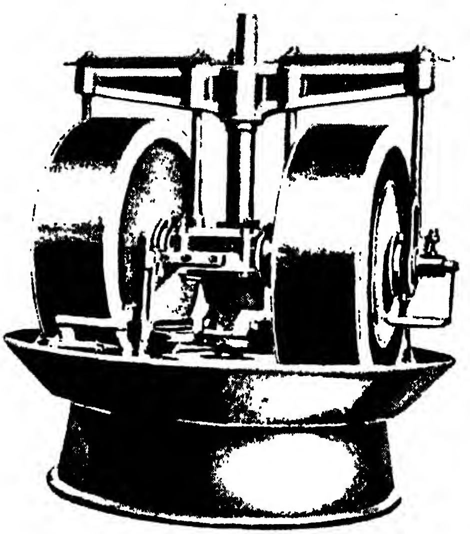
A large proportion of the saltpetre now used on the Continent is prepared artificially, from sodium nitrate or Chili saltpetre, and potassium chloride. These salts are both found native, and by double decomposition they may be converted into potassium nitrate (saltpetre) and sodium chloride (common salt). These salts are then separated from one another by crystallisation, which is rendered possible by their different degrees of solubility in water.

Sulphur. Sulphur, the second ingredient of black powder, is also obtained from the earth, large quantities coming from the numerous mines in Sicily. The crude ore is burnt in heaps, so that the sulphur melts and runs into a receptacle, from which it is drawn off and run into moulds. Before being incorporated into powder it has to be refined. The method in use at Waltham Abbey is substantially as follows. The crude sulphur is introduced into a still which can be closed by a cover. This is in connection with two receivers, one of which is used to collect the vapours before and after the actual distillation, the other to collect the purified sulphur. During the early part of the distillation the vapours are conducted to the former, where they cool in the form of flowers of sulphur. These are collected and re-distilled as crude sulphur. When the vapours from the retort change colour from yellow to purple, they are conducted to the second receiver, which is cooled by water, as is the pipe leading to it. The sulphur condenses in the pipe and runs into the receiver in liquid form. Another source of sulphur, which has come to the front only within recent years, is the Chance process for the recovery of sulphur from the waste-heaps of the soda factories. The sulphur obtained by this process is purified as described above.

Charcoal. Charcoal was formerly obtained by burning wood in large heaps in such a way that it was only partially consumed. This old and extravagant method is now entirely superseded. The wood is subjected to a destructive distillation in closed cylindrical vessels. At Waltham Abbey the plant consists of a large cylinder into which a number of smaller cylinders, charged with wood and closed, are packed. The large cylinder (which is built into a furnace) is heated, the wood is charred and the small cylinders, still closed, are removed while hot, and cooled before they are opened. In this way a great loss of charcoal, due to contact with the oxygen of the air while hot, is avoided. The charring of the wood is also easily regulated.

Within the past century many changes have naturally been suggested in the composition of gunpowder. The use of sodium nitrate as a substitute for potassium nitrate is found unsatisfactory, as the former is a very deliquescent salt. Ammonium nitrate is even less suited to replace saltpetre for the same reason. Potassium chlorate is a salt very rich in oxygen, and many attempts have been made to introduce it into gunpowder, but there are many objections to its use. It is a very dangerous salt to manufacture on account of its great oxidising power and sensitiveness to friction, and powders containing it evolve hydrochloric acid in the gun when fired. The introduction of charred straws to replace charcoal was an important advance, producing a slow-burning powder suitable for large guns, of high efficiency, especially when moulded in the prismatic form, which is described later.

The Grinding Mill. The sulphur, saltpetre, and charcoal are ground to fine powder separately in a grinding mill, which may be of almost any form. In early times the ingredients were mixed, and then ground and incorporated in one operation; but this plan was very unsatisfactory, as the mixture was never sufficiently intimate, and the danger of explosion from friction was much greater. The powdered ingredients are weighed out in the proportions desired, and mixed roughly in a copper drum by means of a revolving shaft fitted with forked arms. Great precautions are taken to prevent any foreign matter, such as scraps of iron, from getting into the charge.



53. INCORPORATING MILL

The roughly mixed charge—a "green charge," as it is called—is thoroughly mixed in an incorporating mill of the edge-runner type [53], the more modern of which have suspended runners, never actually touching the bed. The runners weigh about four tons, and the largest charge mixed at a time is 50 lb. to 60 lb., depending on the nature of the powder. The charge is spread upon the bed of the mill, and sufficient water added to prevent the material rising as dust, but not enough to cause the powder to cake on the runners. During the mixing, additional quantities of water are added as the early supply is evaporated. The mixing lasts from three hours to six hours, varying with the type of powder. A special drenching apparatus is fitted up, which pours water over the incorporating mill in the event of the ignition of the charge. When the mixing is completed, the powder is in the condition of mill-cake.

Breaking the Mill-cake. This mill-cake is broken to a convenient size by wooden hammers, and then passed through a breaking-down machine, which consists essentially of two pairs of brass rolls. The cake is roughly ground on the upper rolls, and falls through on to the second pair, where it is crushed to a fine powder. The pressing of this powder into a hard cake is now carried out, as a rule, by means of a hydraulic press. Alternate layers, consisting of powder and ebonite plates, are built on top of one another on a trench which runs upon the bed-plate of the press [54]. When the pile is of sufficient height, the trench is run on to the bed-plate, and pressure is applied gradually. Naturally, there are many precautions to be observed, and certain peculiarities in the press and method of manipulation; but practical experience is the best, and is, in fact, the only means of becoming acquainted with the details of the process. The pressure is continued for a time, averaging about half an hour. The trench is then withdrawn, and the edges of the cakes cut off, as they are not pressed to the same density as the body of the cake.

The cake has now to be transformed into the shape of grains. It is first broken to suitable size by means of wooden hammers, and then run through a breaking-down machine and sieved to size. The revolution of the disc breaks down the lumps of cake, which, when they are sufficiently small, fall through the perforations on to a second perforated tray with very small holes, through which the too finely pulverised portion is sifted off. This second sieve may be made of hair instead of being perforated, and the first sieve is often in the form of finely-meshed brass gauze. A number of these granulating sieves, with weighted discs, are connected together for economical working. By passing the grains through sieves of various-sized mesh, the powder may be sorted out into the sizes required for various purposes.

Glazing and Drying Gunpowder. The powder is glazed by being rotated in a drum for some hours, the time varying with the size of the granules. After this it is dried. The drying-room is a large chamber heated by steam, in which trays containing the powder are laid out in racks. The temperature employed varies from 100° to 140° F., and the powder takes from six to twelve hours to dry. When dry, the dust which is present among the grains is separated by rotating the powder for some hours in a closed cylindrical sieve, a small quantity of graphite being added to give a final gloss. The powder is again passed

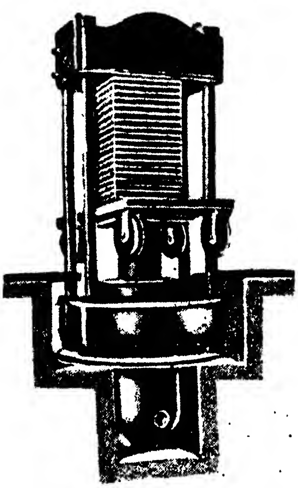
through sieves of various sizes in a final sorting operation to separate the different sizes of grains. The powder is now finished, and requires only to be blended to be ready for use.

Composition of Gunpowder. The composition of gunpowder varies in different countries, and also in accordance with the purpose for which it is destined, but the most largely used formula, and the one most generally accepted, is: saltpetre, 75 parts; sulphur, 10 parts; charcoal, 15 parts. All other formulæ approximate closely to this.

Though black powder has been entirely superseded as a propellant for Service purposes, it is still manufactured in considerable quantities, both by the Government and by private firms. Low-power practice cartridges and some kind of blank cartridges are loaded with it. It is also exported.

Nitro-Glycerin. When Alfred Nobel attempted to adapt nitro-glycerin to practical purposes, he experienced great difficulty in finding a suitable form in which to use it. The first method, that of running the explosive in its liquid form into bore-holes, and then exploding it, was attended with great danger, and many disastrous accidents occurred. The carriage of the "blasting oil," as it was called, was another source of trouble, until it was found that the solution in methyl alcohol greatly decreased the liability to explosion. The alcohol was evaporated immediately before the nitro-glycerin was required for use. Even then, however, the disadvantages of a liquid explosive were numerous, and it was not until Nobel succeeded in finding a suitable absorbent that nitro-glycerin became a success.

Nitro-glycerin is a chemical compound formed by the action of nitric acid on ordinary glycerin. The glycerin used for nitration is practically pure. It must contain only minute traces of mineral matter, and its ash should be below 0·10 per cent. It is prepared by the distillation of the crude glycerin from the soap and candle factories, and in some cases is purified in the explosive factory. Needless to say, the glycerin is thoroughly tested in the laboratory before being used on the manufacturing scale.



54. HYDRAULIC PRESS

The Nitration of Glycerin. Although the active agent in the nitration of glycerin is nitric acid, in practice a mixture of nitric and sulphuric acids is used. When nitric acid acts on glycerin, nitro-glycerin and water are formed. As the action goes on, the increasing quantity of water rapidly dilutes the nitric acid, with the result that the action slackens and side reactions are set up. To obviate this, some body is required which has an affinity for water, and which will absorb it as soon as it is formed. Strong sulphuric acid is found to be the best suited for this purpose, as in the mixture with nitric acid it has no action on the nitro-glycerin. The nitric acid used is, as a rule, prepared in the factory where it is to be consumed, and in some cases a sulphuric acid plant has been fitted up. The proportions of the mixed acids vary in different factories, but on the average the mixture is about three parts of sulphuric to two parts of nitric. The mixing is carried out in large, wrought-iron cylindrical vessels fitted with either air or mechanical stirring to agitate the liquids, and the acid is run from them to "moutejus," or "eggs," from which it is blown under pressure to the nitrating apparatus.

The waste acid—that is, the acid after nitration, from which the nitro-glycerin has been completely separated—varies in composition, but averages 67 per cent. of sulphuric acid, 11 per cent. of nitric acid, and 22 per cent. of water. It is not found to be practicable to make up this waste acid to its original strength, and use it to nitrate a fresh charge of glycerin, so it is subjected to a process of denitration. Various methods are used to separate and recover the acids, and of these the following has been widely adopted. The waste acid, freed from nitro-glycerin, is allowed to percolate from top to bottom of a tower, various devices being made use of to expose as large a surface of the liquid as possible. Steam is passed in at the bottom of the tower, and as it rises it carries away the nitric acid, which is condensed and collected in a dilute state in earthenware receivers. The waste acid, freed from nitric acid, is collected at the bottom of the tower, and consists of dilute sulphuric acid, which is concentrated by evaporation of the water from it.

The amount of acid required to nitrate one part of glycerin varies in different works, but is usually from six to seven parts, and the yield of nitro-glycerin is from 200 per cent. to 220 per cent. of the glycerin used. The Nathan plant gives a yield of 235 per cent.

Nitrating Apparatus. The first operation in the actual manufacture is the nitration. For convenience of working, the whole plant is arranged so that at the conclusion of each operation the nitro-glycerin may flow downwards to the building in which the next stage is carried out. Thus, the nitrating-house is, if possible, situated on the summit of a small hill. If such be not available, the buildings are arranged artificially one above another. In any case the plant is usually known as a "Hill" [55]. The nitrating apparatus consists of a large lead tank, in the interior of which are a number of lead coils, through which cold water or brine flows during the nitration, the object being to keep the temperature down. At the bottom of the tank is a perforated lead pipe, for the admission of air, to keep the contents in a continual state of movement. A lead cover is fitted over the tank, perforated with a small hole through which the thermometer bulb passes down into the acid, and with a large hole connected with a pipe to carry off the acid fumes to a condensing apparatus. Several thick glass windows, circular in shape, are inserted in the cover, so that the contents of the tank may be observed. There is an inlet pipe for the mixed acid, and another for the glycerin, the latter being sometimes sprayed in by means of an air-jet. At the bottom of the tank is an outlet pipe through which the charge is run off when the nitration is finished. During the nitration the outlet pipe is invariably in connection with a large tank of water, called the "drowning tank," so that in the event of any abnormality in the nitration the whole charge may be drowned by the turning on of a cock.

Working the Nitrating Apparatus. The mixed acid is weighed out and run into the nitrating apparatus. When the man in charge is satisfied that everything is in order, he turns on the air pressure, so that the acid is kept in continual movement. Meanwhile, the weighed quantity of glycerin has been run into a small tank, at some height above the nitrator, and connected to the injector by a rubber hose. In winter it is necessary to have the glycerin slightly warmed, so that it will pass readily through the injector. The glycerin is now added in a thin stream, the man in charge of the operation keeping his attention continually fixed on the scale of the thermometer where a red line at the figure 22° C. (71·6° F.) denotes the point above which the mercury must not be allowed to rise. In Germany and other Continental countries nitration is carried out at from 25° C. to 30° C., but in Great Britain 22° C. is the limit. By regulating the flow of glycerin and the supply of water to the coils, the temperature can be maintained constant to a degree during the nitration.

The Separating Tank. When the whole of the glycerin has been added, the charge is allowed to remain in the nitrator until the temperature falls to about 15° C. (59° F.). Then the whole charge is run into the separating tank through a lead pipe. The separating tank is of lead, solidly constructed. Its sides slope down to a glass viewing-cylinder, which is connected to the waste acid tank and to the pre-wash tank. In about 40-45 minutes there is about 5½ in. of nitro-glycerin on top of the acids. This is run into the pre-wash tank. Then the waste acid is run off until nitro-glycerin is seen to be coming into the glass cylinder, when the acid cock is turned off and the rest of the nitro-glycerin run into the pre-wash tank.

The main body of the nitro-glycerin is then subjected to a preliminary washing with cold water in the pre-wash tank. The nitro-glycerin and water are agitated together by a stream of air passing through the tank at a pressure of 50 lb. to the square inch. After three washings a warm solution of sodium carbonate is added to the water for the last washing.

Washing Nitro-Glycerin. The nitro-glycerin is now run out of the pre-wash tank through a series of pipes or covered gutters (the latter being often preferred, as they are more easily cleaned in case of stoppage) to the lead washing in the washing-house. At the back of this building is a small shed, in which the solutions of soda are made up and heated by steam. The sodium carbonate solution and hot water are run into the washing-tank and mixed by air pressure with the nitro-glycerin, the temperature of the whole not exceeding 30° C.

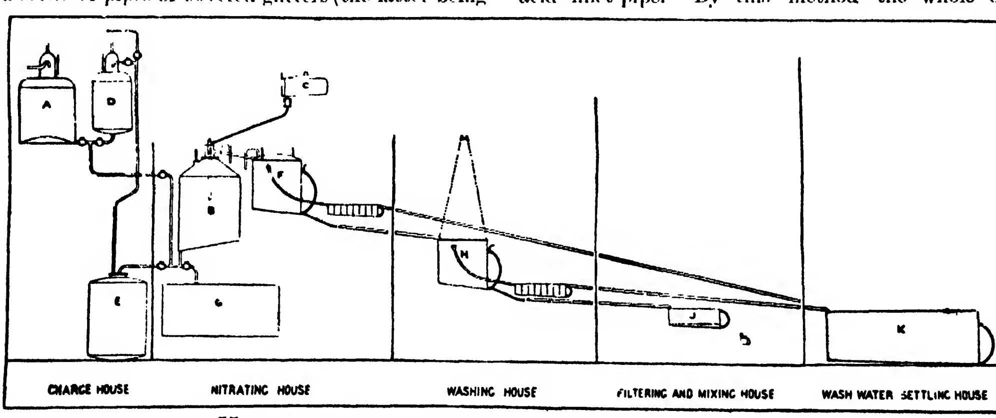
After fifteen minutes' agitation with the soda, the air-supply is shut off, and the soda rises to the top. A few minutes are allowed for the separation of the soda, and the solution is then skimmed off, or run off by means of rubber tubes situated at different levels in the tank, so that the soda solution may be completely removed from the washing-tank without loss of nitro-glycerin.

The washings with soda are repeated three or more times until purification is complete. In early work with nitro-glycerin many of the serious accidents were due to the presence of traces of acid in the explosive. Slight decompositions set in, and the nitro-glycerin gradually became very unstable.

To free the nitro-glycerin from sodium carbonate, one or more water-washes are given after the last soda has been drawn off. The final washing leaves not more than 0·01 per cent. of alkali.

The much-improved nitrating and pre-washing apparatus invented by Nathan, Thomson, and Rintoul has been in use for some years in this country and abroad [**55** and **56**]. In this the circular nitrating vessel is fitted with an inlet for acid at the bottom. At the top is a glass separation chamber, from which a lateral overflow pipe conducts the nitro-glycerin to the pre-wash tank. The mixture of acid is run in from a high tank, and is air-agitated, while the glycerin is sprayed in. The agitation is stopped when nitration is complete and the temperature has fallen slightly.

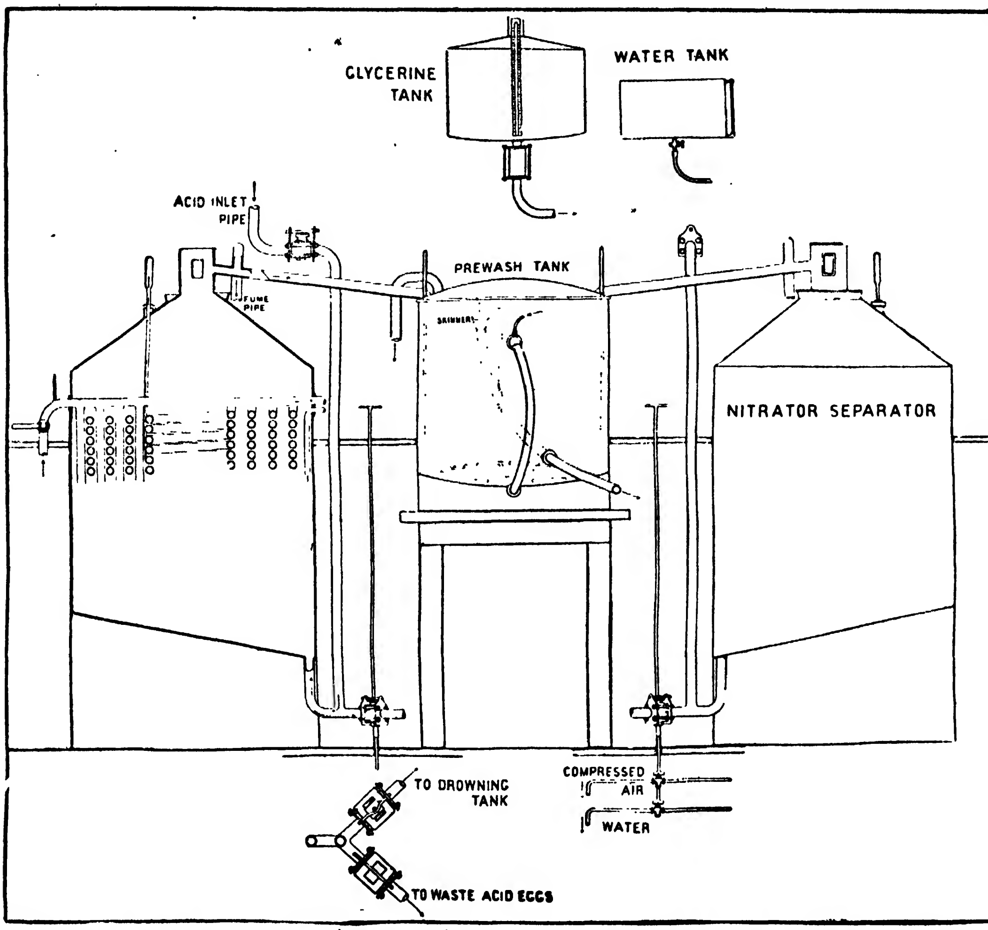
The separation of the nitro glycerin proceeds in the nitrator, and the waste acid from a previous charge is allowed to flow in slowly at the bottom of the tank. By this arrangement the whole charge rises slowly until the level of the clear nitro-glycerin is seen in the glass separation chamber, from which it is displaced into the pre-wash tank, where it is drowned in water, the rate of flow being regulated by means of a cock in the waste acid inlet-pipe. By this method the whole of



55. DIAGRAM OF A COMPLETE NITRO-GLYCERIN "HILL"

A, a measuring vessel, takes a charge of mixed sulphuric and nitric acid, which flows to B, a nitrator-separator. C is a glycerin-measuring vessel, from which the glycerin is sprayed into the nitrator-separator, B, after the charge of mixed acid has been run in from A. When nitration is completed the charge is allowed to separate in the same vessel, B, and then waste acid from a previous charge, having been blown up into tank D by means of the "egg," E, is run in at the bottom of B, thereby displacing the nitro-glycerin through the top of B to the pre-wash tank, F. G is the drowning-tank. After being pre-washed in F, the nitro glycerin is run to the washing-tank, H, where it is finally washed, and then filtered in J. All the wash-water in F and H is collected in the settling-tank, K, where a small quantity of nitro-glycerin settles and is recovered.

By courtesy of Messrs. Nathan, Thomson, and Rintoul



56. DIAGRAM OF NITRO-GLYCERIN NITRATING PLANT, NATHAN, THOMSON, AND RINTOUL PROCESS
This illustration shows on a large scale the arrangement of the nitrator-separators and pre-wash tanks seen in the diagram on page 2780

the nitro-glycerin is recovered with a minimum of trouble, and the necessity of passing the nitro-glycerin through any form of cock is done away with, thus considerably reducing the danger of manufacture. In turning even the most carefully made and lubricated cock there is bound to be friction, and consequent danger.

The Process of Filtering. As a rule, the nitro-glycerin is weighed off in the washing-house. From the washing-tanks it is run into a reservoir tank through a filter, which renders it clear in colour, removing the minute particles of water and foreign matter with which it is mixed. The filter consists of a cloth filled with common sponges. Below the reservoir tank stands a weighing-machine, or measuring vessels may be used to avoid this.

Boxes are brought in containing the weighed quantities of the other ingredients of the explosives. These are placed upon the weighing-machine, tared carefully, and the requisite amount of nitro-glycerin weighed in. The boxes are then removed from the platform of the machine, and the nitro-glycerin mixed roughly with the other ingredients by hand. This obviates the difficulty of conveying the nitro-glycerin from place to place in the liquid state, a proceeding which is fraught with some danger, and is prohibited in Great Britain.

One of the problems of the manufacture of nitro-glycerin is the removal of all traces of the explosive from the acids and washing waters. After all possible nitro-glycerin has been removed from the washing water it drains into a pond, in which periodically dynamite cartridges are exploded to destroy any of the nitro-glycerin which may have managed to escape any of the traps and filtering processes meant to remove it.

The "mud" or sediment which collects in the bottom of the washing-tanks is also treated to remove as much of the nitro-glycerin as possible, and is then mixed with paraffin and fired. The waste acids are "denitrated."

Throughout the whole of the operations described above, great precautions are taken to avoid all chances of explosion. The clothes of the men engaged in the manufacture are made specially for them, and are without any metal buttons. Pockets are also forbidden, so that there may be no temptation to bring unauthorised articles into the danger area. At the door of each building rubber shoes are put on over the boots, so that no grit from outside may be brought into the buildings. The Govern-

ment and factory regulations are posted prominently in every building, and they are read over to the men by their foreman at frequent intervals.

Dangers of Nitro-Glycerin. Of all explosives, nitro-glycerin is one of the most dangerous to handle and manufacture. It will readily be seen that a liquid is less easily removed entirely when the vessels containing it have to be cleaned out. In the case of a spill, also, it is extremely difficult to clean up the last traces. At one time, the floors of all buildings in which nitro-glycerin were used were composed of fine sand, which was frequently changed, but the advantages accruing from this plan were more than neutralised by the danger of grit getting into the apparatus.

In winter, the liability of nitro-glycerin to freeze is a source of much trouble. The buildings are kept heated by steam-heaters, but the pipes and gutters connecting the buildings are very apt to be frozen up in the morning when work is due to begin, notwithstanding all precautions. Nitro-glycerin solidifies at 40° F., so that in even moderately cold weather this trouble occurs. Unfortunately, also, in the solid state, it is much more dangerous to handle. Thus, the mere fracturing of a crystal has been known to cause explosion.

When pure, nitro-glycerin is colourless, but the commercial variety is generally slightly yellow. It is without smell, and has a sweetish taste. It is soluble in benzene, ether, alcohol, and other organic solvents, but insoluble in water. A drop of nitro-glycerin explodes when struck with a hammer on an anvil.

When liquid nitro-glycerin is heated in any quantity, it explodes at about 180° C., though very small quantities have been raised to much higher temperatures without detonating. Of course, continued heating at much lower temperatures (below 100° C.) gradually decomposes nitro-glycerin, and it explodes with violence.

Dynamite and Other Nitro-Glycerin Explosives. As stated above, it was found that the use of nitro-glycerin in the liquid state was too dangerous, and it became necessary to find some means whereby it could be obtained in a more suitable form. The attention of Nobel, among other investigators, turned to the discovery of some substance with which it could be mixed to give a plastic mass which could be easily handled, and which would at the same time retain the explosive properties of nitro-glycerin. Alfred Nobel discovered the suitability of kieselguhr for the purpose, and the explosive made with its aid is used in large quantities to the present day.

Kieselguhr is an infusorial earth, made up of the shells of minute diatoms. It is found in some parts of Germany, and in the north of Scotland, near Aberdeen. The earth varies very much in appearance, that found in Germany being almost pure white, while Scotch "guhr" is dark grey, sometimes almost black.

As found in Nature, kieselguhr contains a large proportion of organic matter, which has to be burnt off before the earth is used. When calcined, kieselguhr is usually of a salmon-pink colour, and very light and impalpable. Under the microscope it is seen to consist of innumerable minute structures (diatoms) of many different shapes. The source of the guhr may often be told by an examination of the diatoms. The latter are hollow or tubular, and are capable of absorbing a large quantity of nitro-glycerin. Dynamite usually contains 25 parts of guhr to 75 parts of nitro-glycerin, and is only sufficiently moist to adhere when pressed.

Preparing Dynamite. Dynamite is prepared almost entirely by hand. The kieselguhr, after it has been calcined, is ground in a mill, and then weighed out in suitable quantities. Considerable care has to be taken with the grinding. It is necessary to break the calcined lumps to powder, but if the milling be carried on over-long, the structures of the shells will be broken down and the absorptive power of the guhr greatly decreased. Thus, samples calcined and mixed with nitro-glycerin in the laboratory show an absorption greater by several points per cent. than the same guhr calcined and ground on the larger scale. The weighed quantities of guhr are placed in large wooden boxes with brass fittings, and conveyed on trucks to the washing-house where the nitro-glycerin is stored. The necessary amount of the latter is weighed in and the box removed from the weighing-machine to a bench, where a workman, with sleeves rolled up to the shoulders, roughly mixes the ingredients with his hands. This rough mixing is given in order that the nitro-glycerin may not be lying in pools in the box during its conveyance from the washing-house to the mixing-house. The boxes are again placed on a truck, and taken to the mixing-house, where the dynamite is thoroughly mixed. A small quantity (usually about ½ per cent.) of sodium carbonate is added, and uniformity of composition is obtained by repeated rubbing by hand through brass sieves. The consistence of the dynamite is of great importance. As it is mostly used by miners, who have their own ideas—mostly without foundation—as to what good dynamite should look like, it has to be prepared to meet their requirements.

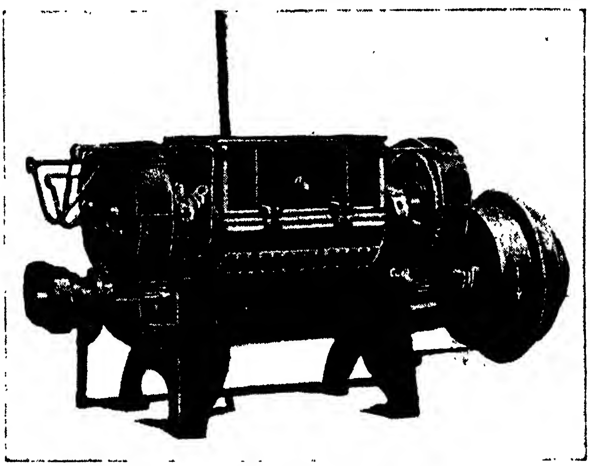
Making Dynamite Cartridges. When mixed and sieved, dynamite is a chocolate-coloured, soft, mealy material, and is ready to be pressed into cartridges. This operation is generally carried out in a machine worked by hand. A funnel-shaped cavity tapers at the bottom into a brass tube the diameter of the cartridge which it is desired to make. A plunger with a brass - or preferably a hard wood—head works up and down in the funnel, pressing the dynamite with which the latter is filled through the tube. The plunger is worked by a lever handle at right angles to it. The handle is pressed down, carrying the plunger down through the funnel, and by means of a spring it rises ready for the next stroke. The operator rolls a cartridge paper round the tube at the bottom of the funnel, folds in the ends, and presses down the lever several times until the paper is filled. The cartridge is then removed from the machine, the upper end of the paper folded in, and the operation is finished. A considerable amount of practice is required in order to know just how much pressure to apply with each stroke of the plunger. Too great pressure forces the dynamite into a solid lump, and causes the nitro-glycerin to exude on to the cartridge paper.

The earlier forms of this machine were very unsatisfactory. The loose dynamite worked its way into the joints of the machine, and in the course of time a bearing heated, or a sharp tap of metal on metal caused the explosive to fire. Immediately the whole stock in the building flared up, and the occupants were lucky if they escaped with their lives. So many modifications and improvements have been introduced that the machine is now almost entirely without danger to the operator. As a rule, several cartridge-machines are fitted to the walls of a small wooden hut, which is isolated—as are all explosive buildings—by high banks of earth or sand.

Disadvantages of Dynamite. The great disadvantage of dynamite in practical use is its liability to freeze in winter. When frozen, it is as hard as stone, and an attempt to insert a detonator into the cartridge would be not only difficult but highly dangerous. Consequently, dynamite must always be thawed in winter before use, and the only safe method of thawing it is to place the cartridge in a warming-pan, which is a water-jacketed pan, within the double walls of which water at 60° C. is contained. A great many of the accidents which take place in the use of dynamite are due to careless methods of thawing. Ignorant workmen heat the cartridges in many reckless ways—by carrying them about in their trousers-pockets, heating them by placing near an open fire, or even by heating them in a tea-can over an open fire.

There are many modifications of dynamite on the market, containing such ingredients as wood-pulp, etc. Sodium carbonate, barium sulphate, ammonium salts, oxide of iron, and other materials are incorporated with other modifications.

Blasting Gelatin. The invention, by Nobel, of blasting gelatin greatly reduced the consumption of dynamite. He found that by mixing nitro-glycerin with collodion cotton, a weakly nitrated cotton soluble in ether alcohol, and heating the mixture, a homogeneous gelatinous mass was obtained, which possessed great advantages over any existing explosive. Roughly speaking, the proportions of the mixture are about 90 parts nitro-glycerin to 10 parts of nitro-cotton, but the quantities vary with different makers. No. 1 gelatin contains 93 to 95 per cent. of nitro-glycerin. The nitro-glycerin is added to soluble cellulose nitrates in the washing-house, and mixed there roughly, as mentioned above. The mixture is conveyed to the gelatin-house, where it is heated in a copper or brass pan, by means of a water-jacket, to a temperature of about 45°-50° C. The pan is fitted with stirrers which keep the mass in movement. Specially modified Werner and Pfleiderer mixers [57] have been largely used. A batch of blasting gelatin is mixed and gelatinised in a short time, usually about an hour.



57. EXPLOSIVE MIXING MACHINE
(Werner, Pfleiderer & Perkins, Ltd.)

The solid gelatinised mass is cut into smaller lumps and carried to the cartridge-making huts, which differ from the dynamite-huts in the cartridge-machines used. The machine is practically an ordinary sausage-machine. It consists essentially of a spiral working within a cover. The gelatin is placed in a small hopper, and the first coil of the spiral catches it and carries it along towards the nozzle, from which it appears in the form of a long, continuous sausage. The whole machine is made of brass, and the spiral is actuated by a shaft turned by hand. Nozzles of different sizes can be fitted to the machine, according to the size of the cartridge desired. The continuous gelatin sausage is cut into suitable lengths by means of a wooden knife, the lengths are rolled in paper, and the cartridges are ready to be packed.

There are many modifications of blasting gelatin, just as there are of dynamite. The method of manufacture is, however, essentially the same. The best known of these are gelatin-dynamite and gelignite, the former being a blasting gelatin containing a certain proportion of wood-pulp, and the latter containing wood-pulp and potassium nitrate. These ingredients are incorporated with the explosive during the process of gelatinisation. Other gelatin explosives are manufactured containing ammonium oxalate.

Cordite. Cordite, which was patented by Sir Frederick Abel and Professor Dewar, is also a gelatinised mixture of nitrated cotton and nitro-glycerin, but in this case the cotton used is guncotton, the most highly nitrated cotton. The mixture cannot be gelatinised simply by dissolving the guncotton in nitro-glycerin, as it is not soluble in it. Consequently, some medium is required to render the gelatinisation possible, and for this purpose acetone is used. The guncotton and nitro-glycerin are mixed together in the required proportions (cordite, as originally used, consisted of 58 per cent. of nitro-glycerin, 37 per cent. guncotton, and 5 per cent. mineral jelly), and acetone is added and hardened into the mass. To this, after about 3½ hours' mixing, the correct amount of mineral jelly is added and the whole mixed for 3½ hours more in a Werner and Pfleiderer mixing-machine. When the mixture is thoroughly gelatinised, it is removed to the press-house to be formed into the cords as it is used. For this hydraulic pressure is required, and special presses have been designed to meet the requirements. The soft "dough" is placed in a steel cylinder and pressed by a tightly fitting plunger through a hole situated at the other end of the cylinder. As the cords are pressed out they are rolled upon reels and removed to a drying-house, where the acetone is evaporated. Large sizes of cordite are not reeled up, but are cut to the required length at once and dried in trays. The temperature at which drying is carried out is about 100° F. The composition of cordite was altered some years ago, and the new explosive was known as "Modified Cordite" (M.D.), and consists of 30 parts of nitro-glycerin, 65 parts guncotton, and 5 parts mineral jelly. The process of manufacture is, however, essentially the same.

Ballistite. Another smokeless powder similar to cordite in some respects is *ballistite*, the invention of Alfred Nobel. It is composed of 50 per cent. of soluble nitro-cotton and 50 per cent. of nitro-glycerin. In this case the soluble cotton will not dissolve directly in the nitro-glycerin, as it does in the case

of blasting gelatin, as the proportion of nitro-cotton is too great. Consequently, a solvent is used as with cordite, in this case benzene (Nobel used camphor). In many respects the process of manufacture is similar to that of cordite, but the form of the finished explosive is different. The gelatinised mass is pressed through heated rolls, and emerges in the form of a thin sheet, which is cut up by another machine into small squares.

Nitro-Cotton. The principle of the manufacture of nitro-cotton is the same as that of the manufacture of nitro-glycerin—namely, the treatment of the substance to be nitrated with strong nitric acid. Here, also, a mixture of nitric and sulphuric acids is used, with the object of removing the excess of water formed. The cotton used is received in the explosive factory in large, compressed bales. It is the waste from the cotton-mills. Before it can be nitrated it must be subjected to a preliminary purification to free it from dirt, grit, oily matter, etc., and to get it into a suitable state of division for nitration. It is then placed in stoves and dried at about 100° C., being withdrawn from the stoves and weighed just when required for use.

The great difference between the nitration of glycerin and cotton lies in the fact that the former, on treatment with nitric acid, always—with one exception—gives the same product—tri-nitroglycerin; whereas cotton gives a whole series of nitro-derivatives according to the constitution of the acid mixture. Guncotton is the compound in which the greatest amount of nitration has taken place, six molecules of nitric acid being combined with two molecules of cotton. Other nitro-cottons have been isolated, containing five, four, three, and two nitro groups. Soluble cotton or collodion cotton is a mixture of these lower nitrated cottons. It is used in the manufacture of blasting gelatin, and also in many other industries. Nitro-cotton of a very low degree of nitration is used for the manufacture of articles of the celluloid class. When very slightly nitrated, its liability to explosion is slight, though it is still highly inflammable. In the following description of the method of manufacture we shall consider guncotton, the most highly nitrated cotton, to be the variety under treatment.

The mixed acid used is prepared as described under nitro-glycerin. It consists, on an average, of one part of nitric acid to three parts of sulphuric acid, both being highly concentrated. A very large excess of mixed acid is required compared with that actually taken up by the cotton. As a result, the waste acid is still fairly strong, and is made up to its former composition by adding more strong acid, and used again for another batch. The strength and purity of the acid are a matter of great importance.

Manufacturing Guncotton. The manufacture of guncotton has been entirely changed within recent years by the introduction of the Thomson Displacement Process. This plant consists essentially of large, flat earthenware pans, provided with perforated false bottoms, also of earthenware, on which the cotton rests. The usual quantity nitrated in each pan is 20 lb. of cotton, which is immersed in 400 lb. of mixed acid, previously run into the nitrating pan through the inlet in the bottom, the cotton being kept immersed in the acid by perforated earthenware plates placed on top. Immediately after the immersion of the cotton in the mixed acid, a thin film of water is run in on top to prevent fumes escaping.

On completion of nitration, water cooled to 40 C.° is run in on top of the pan at a predetermined rate, thereby displacing the surplus acid not absorbed by the cotton. A certain quantity of the waste acid thus recovered is strong enough to be "doctored" with fresh acids and used again, but, as the displacement continues, this waste acid becomes too weak for use, and has to be redistilled and the acid recovered in the form of weak sulphuric acid and nitric acid; by the end of the displacement period the run-off is water only, slightly acid, and it is run to waste.

The chief advantages of the Thomson process over that formerly in use are that all danger of fuming off while nitrating is avoided, the processes of centrifugaling out excess acid and washing in Hollanders are not necessary, and there is an almost complete absence of danger in the operation.

Treatment of Guncotton after Nitration. On completion of the nitration and displacement of waste acid, the guncotton is removed from the nitrating pans and boiled in large wooden vats. These vats are filled with guncotton and water, the guncotton resting on a perforated false bottom under which steam is introduced, and the boiling continued for a considerable period.

Pulping. The pulping, which is one of the most important operations in the manufacture of gun-cotton, is done in the pulping-machine [58]. A revolving drum, the circumference of which is fitted with knives, rotates in a trough. At one part of its course is a set of closely set knives, between which and the knives of the drum the guncotton is crushed and cut. The trough contains a quantity of guncotton in water, and as the drum rotates it carries part of the guncotton round to the fixed set of knives. The space between the rotating knives and the fixed set can be regulated, so that it is comparatively large towards the beginning of the pulping, and is decreased as the operation goes on. The water in the trough may be changed continually, as in the preliminary washing, or the pulping may be carried out with one water, and the pulped cotton washed afterwards with repeated quantities of water. When the pulping and washing are finished, the guncotton should be perfectly free from acid. Samples are drawn from it, and the "heat test" is applied. The guncotton must stand the test for the regulation time. The excess of water is removed by centrifugaling or by a moulding machine, a flannel cloth or bag being placed inside the basket of the machine, as the guncotton is in such a fine state of division that ordinary perforations would not keep it back. If not required for immediate use, guncotton is usually stored wet. As it comes from the centrifugal it contains from 25 per cent. to 30 per cent. of water, and it is stored in closed boxes until required.

Drying Guncotton. The drying of guncotton is carried out in a building with a lead floor and zinc-lined walls. It is fitted with racks for the trays on which the explosive is to be placed. Great care is exercised to prevent grit of any kind from getting into the building. Heat is supplied by blowing in hot air, and the temperature is kept at about 40° C. For some time a method of drying in semi-compressed, cylindrical form has been adopted in some factories, thereby making the process much safer by reducing greatly the quantity of dry guncotton dust present in the store. Guncotton is not usually dried until it is required for incorporation with the other ingredients of the explosive to be made, as it is so much more safely stored wet.

Compressed Guncotton. A very large proportion of the guncotton manufactured is used in the form of compressed slabs. In making com-

pressed cotton the drying described above is not carried out. Guncotton is uniformly mixed with pure water, when the exact weight required for the slab has been weighed out, by means of a stirring arrangement; the wet cotton is placed in moulds, in which the required slab is shaped, and a large part of the water pressed out. The pressure at this stage is usually applied by hand, and the slab, though of the correct shape and area, is still about three times the weight which is required after it has been moulded.

In order to reduce it to the right thickness and the desired solidity, hydraulic pressure is necessary. The pressure used is very similar to an ordinary hydraulic press, capable of exerting a pressure of from 7000 lb. to 15,000 lb. to the square inch, but has certain slight modifications. The finished compressed slabs, if required for building up charges for mines, etc., must be of a smooth surface so that they will fit closely together. In order to get the surface smooth and even, the slabs have to be planed, filed or turned, as their shape makes convenient. The compressed cotton should contain at least 30 per cent. of water in order that this trimming may be done safely, and the surface coming in contact with the tool must be kept cool by a constant application of cold water. When slabs are required with holes through them too small to be conveniently made under the press, they are drilled out in the ordinary way, heating being prevented by means of cold water.

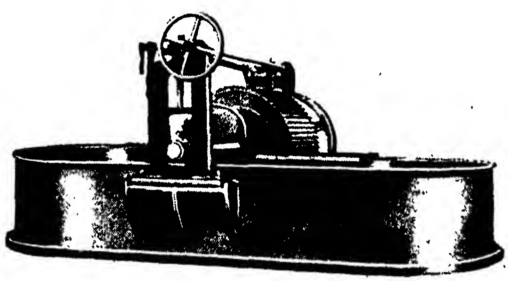
Collodion Cotton. The manufacture of collodion cotton, or soluble cotton, depends for its success greatly on the proportions and strength of the acid mixture. The proportion of the acids averages about 50 parts of nitric to 50 parts of sulphuric, and more water is present, but the time during which the cotton is allowed to remain in contact with the mixed acid is much shorter than in the case of guncotton.

The final processes of boiling, pulping, and drying collodion cotton are on lines similar to those already described for guncotton.

Manufacturing Collodion Cotton. The years that have been spent on the investigation of nitro-cotton have produced much information, a great deal of which has never gone beyond the works in which it originated, but a typical method is as follows.

Quantities of dried cotton of about 1¼ lb. weight are dipped into a tank or "dipping-pan" containing a large excess of mixed acid, the dipping-pans sitting in a trough through which cooling water is circulated. The cotton soaks up about eleven times its own weight of acid in the dipping-pan.

Treatment of Collodion Cotton after Nitration. When the nitration is completed, the contents of the dipping-pans are emptied into a centrifugal machine, the basket of which is made of finely perforated wrought iron. The transference from the dipping-pans to the centrifugal is as rapid as possible, as it is desirable that the nitro-cotton should not be in contact with the air while it contains a large proportion of acid. While in the centrifugal, fuming off or firing is not at all uncommon. When the basket is charged with acid cotton, the centrifugal is set in motion, and the excess of acid is forced out through the perforations. When this operation is completed, the nitro-cotton is removed as quickly as possible from the basket and put under water in a wash tank. Fresh water flows through the tank, loss of nitro-cotton being prevented by a sieve over the outlet pipe. The continuous changing of the water, and the agitation and pressing caused by the paddle-wheel, remove the excess of acid from the cotton. The excess of water is removed in a centrifugal machine. Although the nitro-cotton after this preliminary washing is apparently free from acid, it has been found that this is far from being the case. In the early days of nitro-explosives numerous decompositions accompanied by explosion took place when nitro-cotton was stored for any length of time. Sir Frederick Abel was the first to point out the reason of this. The fibres of the cotton are hollow, and at the end of the nitration are filled with acid. It was found that no amount of washing was sufficient to remove this acid completely, and, until Sir Frederick Abel proposed the disintegration of the fibre by pulping (as described under guncotton), nitro-cotton was a highly dangerous body in practice.



58. PULPING MACHINE

There is no difference in appearance between cotton fibre and nitrated cotton fibre. Of course, after the fibre has been destroyed in the pulping-machine the nitro-cotton loses its characteristic appearance, and on drying is a fine, soft, white dust. Wet guncotton is not considered an explosive, and the rules and regulations regarding explosives do not apply to it until it is dried. Thus the buildings in which it is stored while wet do not need to be isolated like nitro-glycerin buildings. The drying-rooms or stores, however, into which the cotton goes wet, to come out again dry, are considered as explosive buildings, and arranged accordingly.

Other Nitro Bodies. Many other substances have been experimented with, with a view to forming explosive nitro-derivatives, and a number of such compounds are actually in use. Picric acid, which is the tri-nitro derivative of phenol, or carbolic acid, is the most important of these. It is prepared from phenol by first forming a compound of the latter with sulphuric acid and then precipitating the phenol-sulphuric acid by means of nitric acid. The picric acid thus formed must be washed free from sulphuric acid. Picric acid is a bright yellow crystalline solid, which has a very bitter taste, and is slightly soluble in cold water, and more readily in hot water. It was long used as a dye before its explosive properties were discovered. Its principal application in the explosive industry is in the manufacture of the French explosive, melinite, and the British lyddite. In its original form, melinite consisted of 30 per cent. of guncotton and 70 per cent. of picric acid, but it is stated to be greatly altered. The composition of lyddite is not generally known, but it is stated to be picric acid

melted, and run into moulds, together with an oxidising agent.

The nitro-derivatives of benzene and its homologues are also used in the preparation of explosives. They are not so highly explosive as nitro-glycerin or nitro-cotton, but in combination with oxidising agents they are frequently used. Thus roburite is a mixture of di-nitro-benzol with ammonium nitrate. Another such explosive is composed of nitro-toluol and potassium chlorate.

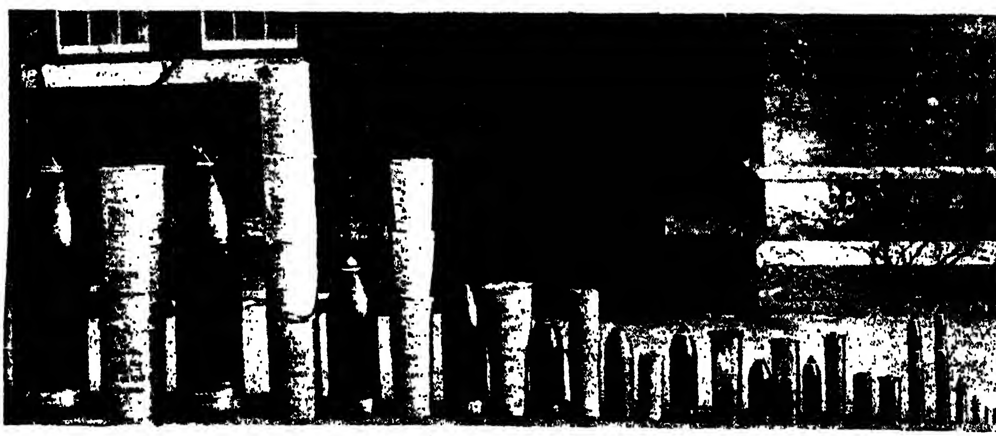
Detonators. A considerable industry connected with explosives is that of making percussion caps [see page 2649] and detonators. The detonators now used for exploding charges in mines, etc., may be said to be simply very largely percussion-caps. Mercuric fulminate is the substance always employed. It is prepared by acting on 1 part by weight of mercury with 10 parts by weight of nitric acid (sp. gr. 1·4), the solution heated, and 8·3 parts by weight of methylated spirit added. The fulminate settles in crystals, which are thoroughly washed. Still in its wet state, the fulminate is taken to drying-rooms, where it is spread on the topmost of a series of layers of cloth which cover a steam-heated copper table. The water is driven off at a low heat, and, when cool, the fulminate is taken to the mixing-room, where it is mixed with 25 per cent. of chlorate of potash.

59. THE NEW EXPLOSIVE, T.N.T.
On the left is a copper-plated block of this powerful explosive, as used in mining. It is so extraordinarily inert that it can be struck by a bullet at short-range without exploding, as seen in the right hand specimen.

The detonator factory, for its size, occupies a good deal of ground, the huts being placed widely apart, and surrounded with high brick walls or mounds of earth. The detonator tubes are made of drawn copper, and vary in length from $1\frac{1}{2}$ in. up to 6 in. The average diameter is about the thickness of an ordinary lead-pencil. The tubes are filled into plates containing one hundred, and are charged with the mixed fulminate. The fulminate is subjected to pressure sufficient to reduce its bulk to one-half its loose state. The detonators are then cleaned and packed in boxes containing sawdust. Fulminate of mercury is an extremely sensitive substance, a scratch with a pin being sufficient at times to explode it. These detonators in use are ignited by means of safety fuses, or by means of electricity. Safety fuses are simply a train of gunpowder contained in a tube of fabric covered with a more or less water-resistant material, such as pitch. Electric fuses are made on two systems, which have been named high and low tension. The former consists of a readily ignitable mixture covering the ends of the wires, which are fixed in the detonator tube in close proximity to the fulminate. The latter consists of a bridge of fine platinum wire connecting the ends of the two wires and surrounded by a fine dry guncotton. When a current of electricity is passed over the wire, it sets fire to the combustible substance, which in turn ignites the fulminate, and this, being placed within or in close contact to the charge of explosive, detonates the latter.

The latest Service high explosive is tri-nitro-toluol, known officially as T.N.T [59]. This explosive is almost ideal. It is singularly inert until fired with a detonator, when it explodes with great force. It can be melted and cast into any desired shape; it can be machined, drilled, or cut with a saw; it can be carried loose in a soldier's pocket without fear of disaster, for the blow given by a rifle-bullet at even short range will not explode it. In its ordinary form, as sent out from the recently erected factory of the Explosives Loading Company, near Faversham, it is in copper-plated blocks of various shape and sizes, depending on the use to which it is to be put. The thin copper covering is deposited by electricity in the ordinary way, and then covered. The explosive requires no other case for protective purposes. It is of a stability hitherto unknown, and is, at the same time, of maximum efficiency.

The diagrams on pages 2780 and 2781 are by courtesy of Sir Frederick Nathan, who has also given much assistance in bringing the nitro-explosives sections up to date.



SHELLS AND THEIR EXPLOSIVE CHARGES AS USED IN THE BRITISH NAVY

Spacing. Correspondence. Headings. Tabular Work. How to Set Out Addresses. Carbon Work. Manifolding.

TYPEWRITING PRACTICE

It is now time that the student should begin to apply the principles which have been laid down. The only way to master the keyboard is to pick out the letters, striking them one by one, from A to Z, until the exact position of each is quite familiar.

Then should follow the practice of words, remembering that each letter must be struck firmly and evenly, and that prefixes like "ly" and "ing" should not, because of their familiarity, be hurried so that one letter prints unduly near the next.

The necessary space between each word is obtained by striking the space bar, which moves on the carriage—in most machines—the distance of one letter, and the paper is then in position to receive the next impression.

When the student has thoroughly mastered the keyboard, he should begin to practise such exercises as the specimen letter given on this page.

June 25 1914

Messrs Brandon & Webb
107, Broadway Mansions
London, E.C.

Dear Sirs,

We have to acknowledge receipt of your favour of the 24th inst., and regret that you should have cause for complaint with respect to the delivery of the goods on the 18th inst

We are having the matter looked into and will write you further without delay.

Yours faithfully,
JONES & BROWN

The word "Messrs." should be typed some little way in from the margin of the paper, the margin "adjuster" for most purposes being set on space 5.

Spacing. This brings us to the question of "spacing." If the student turns to the front of his machine he will find a scale which consists of spaces, each corresponding with the width of a letter. These little spaces are divided up into groups of five, and numbered in tens.

This scale corresponds with the one behind the roller, so that if the student wants an ordinary narrow margin, as in general correspondence, he slides the little "margin adjuster" along the back rod until it is on 5. For other classes of work, he will require a wider margin, in which case the adjuster may be set on 10, or, for foolscap work, on 15.

It sometimes happens that the operator may want to add an occasional figure or reference in the left-hand margin, and, by a simple arrangement which is fixed to nearly all the latest patterns, he is enabled to do so, without losing time, by touching a lever fixed to the carriage. By this same stop he is able, if necessary, to write a letter or two beyond the regular right-hand margin. This is useful when a word which is difficult to split up into convenient syllables happens to fall at the end of the line.

Special care should be given to the right-hand margin. It is obviously impossible always to avoid a broken appearance, but occasionally, by careful judgment in the division of words, much may be done to improve the look of the page.

Punctuation Marks. After a full stop, an exclamation, or interrogation mark, three spaces should be left; after a semi-colon or colon, two spaces; after a comma, one. Brackets should be divided from the rest of a sentence by one space before and one after; but there should be no space between the brackets and the words they enclose.

Let us now return to our letter. Having started "Dear Sirs" on 5, we should begin the word "We" on the line below, immediately following the comma. This is merely for the sake of appearance; all subsequent paragraphs begin on 10, the words "Yours faithfully" starting on about 35.

When a new line is wanted, the "line-spacing lever" is pushed up, and the carriage shifted back to the margin, which introduces us to another kind of spacing—the spacing which fixes the distance between lines.

In the majority of cases a letter should be written in "double" spacing. Most machines are arranged for three kinds of line spacing—single, double, and triple, which is determined by a simple arrangement at the side of the roller, varying with every make of machine.

Double spacing is generally used for correspondence, although some people prefer the close (or single) spacing adopted by many American firms. In this case, it should be remembered that the somewhat cramped appearance of the page is very considerably lessened by leaving a double space between paragraphs.

Correspondence. But we have so far dealt only with the actual body of the letter. We have still to consider the date and address. The former should begin on about 50, and the name and address, which may come either at the

beginning or end of the letter, starts on 5, each of the following lines being indented five spaces.

In displaying the wording on the envelope, the student must exercise discretion, as the effect necessarily depends on the length and style of the address. In such an address as

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Llewellyn Baumer Esq.,
          37, Albany Road,
                   Hampstead, N.W.
```

each line is indented about nine spaces, although in the case of a long address single spacing should be used, and the steps closed up a little more to prevent a straggling appearance.

```
Mr. William Dimsdale,
     Dept. 7,
          The Roxburgh Printing Co.,
               Wellington Road,
                    Bournemouth, W.
```

In such an address, an indention of five spaces in each line is quite sufficient for display. Where, as in this case, a very short line comes between two longer ones, it should be centred.

An address of two very unequal lines should be written in this way:

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Messrs. Johnston & Turner, Ltd.
             YORK.
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Certain modern machines are fitted with a device known as the column selector, which enables the operator to bring the carriage instantly to any of the five different writing-points of the paper, which points may be determined anywhere along the writing-line.

Mistakes. Although it should be used as little as possible, it is perhaps as well to assume that the student may occasionally have to resort to the eraser. For a serious error, it is very often the wisest course, and in the long run the quickest, to tear out the sheet and start again. Where this cannot be done, a piece of the special typewriter eraser which can be bought at any stationer's—the round pattern with the little metal disc is by far the best—should be used. The student should never attempt to erase a letter from a sheet of thin paper which is not protected from the roller by a "backing" sheet. It is important that such a sheet—any paper of a fairly thick substance will do—should be placed next the roller when foreign or thin paper is used.

The rubber is used *across*, and not *down* the paper, so that the faint smear, which it is almost impossible to quite get rid of, is hidden by the words on either side.

In a very few cases it is allowable to write *over* a letter. An *e*, for instance, may be written over an *o*, a *t* over an *i*, an *o* over a *c*, and so on; but this should only be done where the correction is not apparent.

When writing at high speed the space between two words may sometimes be forgotten, which will quite spoil the effect of a page. Many people are content to run a line through to divide them, either using the shilling mark, which is bad, or a pen, which is worse. Nothing spoils a page of typewriting so much as an ink correction. A far better way of getting out of the difficulty is to rub out the last two letters of the first word, pull the paper along half a space, write one letter, pull it along the same distance, and write the other letter, thus getting three letters within the space allowed for two. This needs practice and a nice judgment, but the effect is worth the trouble.

Centring. Where it is necessary to "centre" a heading, the number of words—including the space between each—should be counted and subtracted from the number of units on the scale bar [72] *minus the margin*, and the result halved. Then add the margin, and you have the exact figure on which to start the line.

In other words, find out the number of spaces your heading takes (say 30), subtract it from the *actual working line* (62—we will assume a margin of 10), and you have 32. Halve it, (16); add the margin (10), and 26 is the number on which to begin the heading.

If it is remembered that the heading has to come *in the centre of the typewritten manuscript*, the calculation becomes quite simple. In the case of a second heading following immediately below, the bottom line is sometimes improved by being spaced out, especially if both lines are of equal length. One space should then be left between each letter, and *two* between the words, as in

```
  SELF EDUCATION
K E Y  T O  S U C C E S S
```

Tabular Work. For setting out columns of words or figures, the old way was to type out the top lines on a rough sheet of paper, see exactly how best to arrange the columns, and make a note of the numbers on which to begin each set of figures.

Supposing one has to type five sets of figures to the line, it is quite easy to divide the columns up equally and remember to start the first letters of each on 5, 20, 35, 50, 65. It also avoids the necessity of lifting the carriage repeatedly.

Tabulators. Where a great deal of this class of work has to be done, it is desirable to have a device which is known as a "tabulator" fixed on to the machine, which automatically shifts the carriage from one fixed point to another without the use of the space bar.

The Key Set Inbuilt Tabulator found on the No. 11 Remington machine is a modern development of this idea.

Position. It is important that the operator should be seated comfortably. The correct position is that in which the elbows of the typist come about level with the keyboard. If possible one of the tables specially designed to hold typewriting machines should be used. The chair, too, should receive consideration. Those with a small, hard seat, and a straight back are most comfortable. Where much copying from manuscript has to be done a "copyholder" is a great comfort. It saves unnecessary bending, and

if placed *behind* the machine, does much towards preserving the eyesight.

For the figure 1, the small "l" is used, and, for the nought, the capital "O."

CARBON WORK

When two or more copies of a page are wanted, a "carbon" is placed between each sheet, so that the shiny surface touches the page on which the impression is to be made. Great care must be taken in arranging the pages to see that some of the sheets are not reversed, or the result will not be a happy one. The surest way to avoid this is to lay the typewriting paper before you, heading upwards, and place the carbon so that the shiny surface covers it; then the next sheet with the heading up and carbon face downwards, and so on.

Thin paper must be used for this work, with the exception of the bottom sheet, which, to get the best results, should be of thicker make.

The keys should be struck very sharply for carbon work, and care taken to avoid handling the sheets more often than is absolutely necessary, as even the best makes are liable to smudge.

Erasures in carbon work should not be made in the usual way, or the preparation on the surface of the carbon will smear. The best way to remedy an error is to turn back the roller a little, insert a piece of paper between each carbon sheet and the writing, and rub out the wrong letter on each sheet separately. The slips of paper can then be removed, and the letter or word re-typed. But the operator must be careful that in turning back the roller the "pad" is not shifted.

If a faint, dark impression appears on the sides of the copies when the work is taken out of the machine, it is probably due to the fact that the little rubber clips which hold the paper firmly to the roller have not been pushed back.

MANIFOLDING

It is sometimes necessary to take 50 or 100, or more, copies of a single sheet of typewritten matter when there is not time to type each page separately. The process by which this is effected is known as *manifolding.*

The method is very simple, and easily explained. In the first place, the ribbon has to be removed, or, in some machines, merely put out of gear. The words are then typed on to a wax sheet, which, being soft and impressionable, receives the perforations of the type letters. Through these, by means of a duplicator (which may be purchased for about £2), the ink passes, and so leaves an impression on the paper.

Method. When the student has removed the ribbon, and seen that the type is perfectly clean, he should take the yellow oiled sheet from the roll supplied with the machine, and place it in the centre of the wax. Fold over very carefully the top and the sides, and then place over them the tissue sheet (which is merely to protect the wax), and turn in the top edge slightly to prevent its slipping when it is put in the machine.

As in carboning, the rubber clips on either side of the roller should be removed.

Then put the pad you have made into the machine just as if you were feeding an ordinary sheet, so that the impression is made directly on the tissue sheet. The matter must be very slowly and carefully typed, as mistakes are not easy to rectify. The keys should be struck evenly and smartly, but the "o's" must have a lighter depression, or the centre of the letter will fall out when the wax sheet is removed, and cause the ink to make a blot on the paper.

Mistakes may be erased by means of a special varnish, but it takes some little time to dry, and should, therefore, only be used as a last resort.

When the matter is typed, take away the oiled sheet, and then, very carefully, the tissue, which will need careful handling to prevent the surface of the wax being spoiled. All that we are concerned with now is the wax sheet, or "stencil," which is placed, face upwards, on the duplicator and covered with the "flimsy." Unfasten the steel frame, place it *under* the wax sheet, and then, with the sheet round it, lift it and fix it back into its place at the top of the apparatus.

The stencil must be very carefully adjusted. When in position it should be stretched as tightly as possible without tearing it. It must also be remembered that the least crease or crack on the wax sheet means an undesirable perforation, and so renders it unusable.

Now turn to the slate, on which enough ink should be squeezed to make a thin paste when rolled out, and evenly distributed. Next lift the upper part of the machine, cover the "baseboard" with blotting paper, replace the former, and pass the ink roller firmly over the stencil.

Pass the roller backward and forward until the impression is seen plainly on the blotting paper, which should be renewed two or three times until every letter is quite clear.

Then the sheet on which the impression is to be made can be put over a clean piece of blotting paper, and as many impressions rolled off as necessary. From a carefully prepared stencil, 300, or more, copies may be taken.

Two points should be remembered. In typing matter for manifold work see that each letter is struck with a uniform force; and use only just sufficient ink on the roller to give a clear, sharp result.

The process which has been described applies particularly to the "Ellam's" Duplicator. If, however, the "Roneo" is to be used, practically the same instructions apply, as in both cases a stencil has to be prepared.

MARGARET LILLIE

Problems Leading to Simple Equations with One Unknown Quantity. Problems Leading to Simple Simultaneous Equations.

ALGEBRAIC EQUATIONS

PROBLEMS LEADING TO SIMPLE EQUATIONS

51. By the aid of Algebra we are able to solve problems the solutions of which by Arithmetic are either impossible or very laborious. We have simply to express the conditions of the question in algebraical symbols. This gives us one or more equations, the roots of these equations being the unknown quantities which the problem requires us to find.

We shall first consider problems in which there is only *one* unknown quantity, and in which the conditions of the question lead to a simple equation—*i.e.*, an equation of the first degree.

Example **1.** The difference between two numbers is 5; if 2 be added to the greater, the result is twice the smaller. Find the numbers.

Here, although we have to find *two* numbers, we may still consider the problem as containing only *one* unknown quantity. For, if we can find, say, the greater of the two numbers, we obtain the other by subtracting 5. Suppose, then, that

$$x = \text{the greater number.}$$

It follows that

$$x - 5 = \text{the less number.}$$

Now, the question tells us that if we add 2 to the greater number, the result is twice the less.

But, by adding 2 to the greater number we obtain $x + 2$, and twice the less number is $2(x - 5)$.

Hence we have the equation

$$x + 2 = 2(x - 5).$$

Removing the brackets, and transposing the terms, we get

$$2x - x = 2 + 10;$$

or,

$$x = 12.$$

Thus, the greater of the two numbers is 12, and the other number is $x - 5$, *i.e.*, $12 - 5$, or 7.

Example **2.** The sum of £8 12s. 6d. is paid with 30 coins, some of which are half-crowns, and the rest are half-sovereigns. How many are there of each sort?

Let x = the *number* of half-crowns.

Then, since there are 30 coins altogether, the number of half-sovereigns must be $30 - x$.

We have now to express algebraically the fact that x half-crowns and $(30 - x)$ half-sovereigns make a total of £8 12s. 6d. We must be careful in forming our equation that all the quantities involved are expressed in terms of the same unit. In this particular case it is convenient to work in half-crowns.

We know that a half-sovereign equals 4 half-crowns.

Therefore,

$(30 - x)$ half-sovereigns equal $4(30 - x)$ half-crowns.

Also, £8 12s. 6d. equals 69 half-crowns. We have, then, simply to write down the statement algebraically that x half-crowns and $4(30 - x)$ half-crowns make 69 half-crowns. Thus

$$x + 4(30 - x) = 69.$$

Solving this equation in the ordinary way, we find that $x = 17$, and therefore $30 - x = 30 - 17 = 13$. Thus the solution of the problem is that there are 17 half-crowns and 13 half-sovereigns.

Example **3.** A has as many florins as B has half-crowns. If B gives A two of his half-crowns they will then have equal amounts of money. How much had each at first?

Let x = the *number of coins* each has at first. When B has given A two half-crowns, B will have $(x - 2)$ half-crowns, and A will have x florins + 2 half-crowns.

Expressing the values in sixpences, we see that B has $5(x - 2)$ sixpences (for 5 sixpences make half-a-crown), and A has $(4x + 10)$ sixpences.

Hence,

$$5(x - 2) = 4x + 10.$$

The solution of this equation is

$$x = 20.$$

Therefore,

A had 20 florins, or £2,
B had 20 half-crowns, or £2 10s.

Example **4.** A man's age is 38, his son's is 16. When was the father 3 times as old as the son?

Let x = number of years which have passed since the father was 3 times as old as the son.

Then, x years ago the father's age was $38 - x$, and the son's was $16 - x$, so that

$$38 - x = 3(16 - x).$$

This gives $x = 5$, so that the required solution is, 5 years ago.

Example **5.** A number consists of two digits whose sum is 9. If the digits be interchanged, the number so formed exceeds the original number by 45. Find the number.

Let x = the digit in the units' place.

Then, since the sum of the digits is 9,

$$9 - x = \text{the digit in the tens' place.}$$

Probably, the beginner's only difficulty will be in writing down the number. But he has only to think of the meaning of a number expressed in the ordinary notation.

The number 37, for example, means 3 tens + 7 units. In the same way, then, if $(9-x)$ stands for the tens' digit, and x for the units' digit, the value of the number is

$$(9-x) \text{ tens} + x \text{ units},$$

i.e.,

$$10(9-x)+x.$$

Similarly, if the digits are interchanged, the number obtained will be

$$10x+(9-x).$$

The question tells us that the second of these exceeds the first by 45.

Hence,

$$\{10x+(9-x)\}-\{10(9-x)+x\}=45.$$

Solving this equation, we obtain $x=7$. Thus, the units' digit is 7, and the tens' digit is $9-7$, *i.e.*, 2. The required number is, therefore, 27.

EXAMPLES 9

1. Find two numbers whose sum is 63 and whose difference is 7.

2. Find the number which, when multiplied by 3, is as much above 18 as it was originally below 18.

3. Divide 39 into two parts such that twice one part is 2 less than three times the other.

4. Divide 69 into three parts such that the first shall be double the second, and the second be 3 more than thrice the third. [Let x = the third part.]

5. Find a number such that the product of one more than its double and one less than its half may be 10 less than its square.

6. A father's age is three times his son's age. In 12 years the father will be twice as old as the son. What are their present ages?

7. The united ages of three sisters make 47. The youngest is 3 years younger than the second, and the second is 5 years younger than the eldest. How old are they?

8. A sum of money is divided between A, B, and C, so that A and B have £39 between them, B and C have £26, and A and C have £31. Find the amount each has.

9. There are 81 coins, of which some are crowns and the rest are shillings. If the crowns were florins and the shillings were half-crowns, the total value would be unaltered. Find the number of coins of each sort.

10. If 12 oranges cost as much over 10d. as 20 cost under half-a-crown, how many oranges can be bought for five shillings?

11. Of two squares of carpet, one measures 16 feet further round than the other, and contains 64 square feet more in its area. Find the length of the side of each square.

12. A purse contains 26 coins, whose total value is £6. A certain number of the coins are sovereigns, there are three times as many half-crowns, and the rest are shillings. How many coins are there of each sort?

13. If A gave B ten shillings he would have three times as much as B; while if B gave A five shillings, A would have four times as much as B. How much has each?

14. Find three consecutive numbers whose continued product is 5 less than the cube of the middle number.

15. A number of two digits is such that one digit is three times the other, and if the digits be interchanged the number so formed exceeds twice the original number by 10. Find the number.

PROBLEMS WITH TWO UNKNOWN QUANTITIES

52. We will now consider problems with *two* unknown quantities involved. Many of the questions already given did, as we saw, contain two unknown quantities, but they were of such a nature as enabled us to form an equation containing only *one* unknown. Even when this is possible the work is often simplified if we take two unknowns, and from the conditions of the question form two equations.

Example 1. 6 lb. of tea and 8 lb. of sugar cost 11s. 2d., and 5 lb. of tea and 2 lb. of sugar cost 8s. 4d.; find the cost of each per lb.

Let

x = cost of 1 lb. of tea, *in pence*

and

y = cost of 1 lb. of sugar, *in pence*.

[NOTE. Always be careful to state exactly what the unknown quantities x and y are intended to represent. They will, of course, always stand for *numbers*, but it must be made clear whether it is a number of *pence*, or *shillings*, or *miles*, as the case may be. Such a statement as "Let x = price of 1 lb. of tea" is much too vague.]

Therefore 6 lb. of tea cost $6x$ pence, and 8 lb. of sugar cost $8y$ pence. The total cost is thus $(6x+8y)$ pence. But the question tells us that the cost is 11s. 2d., or 134 pence. Hence,

$$6x+8y=134. \quad . \quad . \quad . \quad (1)$$

In the same way, since 5 lb. of tea and 2 lb. of sugar cost 8s. 4d., we have

$$5x+2y=100. \quad . \quad . \quad . \quad (2)$$

By solving (1) and (2) we obtain

$$x=19,\ y=2\tfrac{1}{2}.$$

Thus, 1 lb. of tea costs 19d., or 1s. 7d., and 1 lb. of sugar costs $2\frac{1}{2}$d.

The above problem is an example in which, although it is not *necessary* to use two unknown quantities, the work is simpler if we do so. Using only one unknown, the problem would be solved as follows:

Let

x = cost of 1 lb. of tea, in pence;

then $6x$ pence = cost of 6 lb.

But 6 lb. of tea and 8 lb. of sugar cost 134d.

Therefore 8 lb. of sugar cost $(134-6x)$ pence; or,

$$\frac{134-6x}{8} = \text{cost, in pence, of 1 lb. of sugar.}$$

Hence, since 5 lb. of tea and 2 lb. of sugar cost 100 pence, we have

$$5x+\frac{2(134-6x)}{8}=100.$$

The solution of this gives $x=19$. The cost of the sugar is then obtained by substituting the value of x in the expression

$$\frac{134-6x}{8}.$$

Example 2. The wages of 7 men and 11 boys for a day amount to £2 1s., and 2 men receive 6d. less than 5 boys. Find the daily wages of a man.

Let

$x =$ number of shillings a man earns per day, and

$y =$ number of shillings a boy earns.

Then 7 men and 11 boys will earn $(7x + 11y)$ shillings.

Therefore,

$$7x + 11y = 41. \quad . \quad . \quad . \quad (1)$$

Again, $2x$, the amount earned by 2 men, is 6d. less than $5y$, the amount 5 boys earn; so that $2x$ shillings and $\frac{1}{2}$ shilling make $5y$ shillings.

Therefore,

$$2x + \tfrac{1}{2} = 5y. \quad . \quad . \quad . \quad . \quad (2)$$

Clearing (2) of fractions, and transposing, we have

$$4x - 10y = -1. \quad . \quad . \quad . \quad (3)$$

Multiply (1) by 10 and (3) by 11, and add. Then

$$70x + 44x = 410 - 11;$$

or,

$$114x = 399.$$

Therefore,

$$x = 3\tfrac{57}{114} = 3\tfrac{1}{2} \text{ shillings.}$$

Hence, a man's daily wage is 3s. 6d. *Ans.*

Example 3. A has three times as many shillings as pennies, and B has three times as many pennies as shillings. If A has 7d. more than B, and together they have two more pennies than they have shillings, how much has each?

Let

$x =$ number of pennies A has;

then

$3x =$ number of shillings A has.

Similarly, if

$y =$ number of shillings B has,

then

$3y =$ number of pennies B has.

We obtain one equation from the fact that, together, they have 2 more pennies than shillings. Thus,

Total number of pennies $= x + 3y$,

and,

total number of shillings $= 3x + y$.

Therefore,

$$x + 3y = 3x + y + 2;$$

or, transposing, and dividing by 2,

$$x - y = -1. \quad . \quad . \quad . \quad . \quad (1)$$

We obtain the second equation from the *values* of the sums of money A and B have. Thus, A has x pennies and $3x$ shillings, that is $(x + 36x)$ pence, in value. Similarly, B has $(12y + 3y)$ pence, in value. Hence,

$$x + 36x = 12y + 3y + 7;$$

or,

$$37x - 15y = 7. \quad . \quad . \quad . \quad (2)$$

from (1) and (2) we find $x = 1$.

Hence A has 1 penny, and, consequently, 3 shillings. His total is thus 3s. 1d. This is 7 pence more than B has, so B has 2s. 6d.

Example 4. A number of three digits has its tens' digit double of the units' digit. It exceeds by 99 the number formed by reading the digits backwards, and the sum of these two numbers is 585. Find the original number.

Let

$x =$ digit in the units' place;

$y =$ digit in the hundreds' place;

then $2x =$ digit in the tens' place.

Then the number is $100y + 20x + x$. [Compare Art. 51, Ex. 5.] If the digits are read backwards, the number is $100x + 20x + y$. Hence,

$$(100y + 20x + x) - (100x + 20x + y)$$
$$= 99; \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$(100y + 20x + x) + (100x + 20x + y)$$
$$= 585. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Collecting terms, we get from (1)

$$99y - 99x = 99;$$

or,

$$y - x = 1. \quad . \quad . \quad . \quad . \quad (3)$$

and, from (2)

$$141x + 101y = 585. \quad . \quad . \quad . \quad (4)$$

Solving (3) and (4) we find $x = 2$, $y = 3$.

Hence, the units' digit is 2, the tens' digit is twice 2, and the hundreds' digit is 3.

The required number is thus 342 *Ans.*

EXAMPLES 10

1. Find two numbers such that their sum is less by 2 than five times their difference, and three times the greater exceeds four times the less by 7.

2. In another year a father will be four times as old as his son; 2 years ago he was three times as old as his son will be in another 3 years. Find their present ages.

3. A number of two digits exceeds 5 times the sum of the digits by 7, and exceeds by 9 the number formed by reversing the digits. Find the number.

4. A, B, C, and D have £100 amongst them. C has twice as much as A, and B has three times as much as D. Also, C and D together have £2 10s. more than B. How much has each?

5. In 2 years' time a father will be three times as old as his elder son, and five times as old as his younger son. In 23 years' time his age will be equal to the sum of his sons' ages. How old is each of them now?

6. In 8 hours A walks 8 miles more than B does in 5 hours, and in 9 hours B walks a mile more than A does in 10. How many miles does each walk in an hour?

7. A and B have a guinea between them. If A gives B a shilling for every penny B has, A will have 5s. less than B. How much has each at first?

8. A takes $5\frac{1}{4}$ hours more than B to go a distance of 60 miles. If A had doubled his pace he would have taken 5 hours less than B. Find the rate at which each travelled.

H. J. ALLPORT

END OF VOLUME THREE

GEOLOGICAL MAP OF THE BRITISH ISLES

THE ROCKS OF OUR OWN COUNTRY—FROM THE MOST ANCIENT TO THOSE OF RECENT TIMES

Quaternary		Alluvium	16
Tertiary			15
Secondary	Cretaceous	Chalk	14
		Greensand, Gault, &c.	13
	Jurassic	Oolites	12
		Lias	11
	Triassic		10
Primary	Permian	Magnesian Limestone	9
		Marls, Sandstones, &c	9*
	Carboniferous	Coal Measures	8
		Millstone Grit	7
		Limestone	6
Primary *continued*		Devonian	5
		Upper Silurian	4
		Lower Silurian	3
		Cambrian	2
		Archæan	1
Eruptive Rocks			E
Metamorphic Rocks			M

Almost all the important geological strata are found in the British Isles cropping up in different places. This map indicates where they are to be found, and the above table sets out the names by which they are known, the numbers on the map corresponding with the names in the table.

The Scarcity of Genius and the Reason why its Discoveries should be Widely Spread

SOWING AND HARVESTING IDEAS

There is a good deal to be said for the view that the progress of mankind has been due to a very limited number of individuals. Today, in the twentieth century, we profit by the possession of a great body of lore which has been accumulated during thousands of years. In every hour of our lives we employ processes, or enjoy the fruits of processes, which have been discovered for us by clever individuals, most of whom are dead, but some of whom are still with us.

All nations have made their contributions to this common stock of knowledge which is our heritage, but, when we come to examine the facts, it is astonishing to find how few is the number of persons who have contributed great new ideas, inventions, or discoveries. In any branch of learning, or art, or science, a list of the chief contributors, including both the dead and the living, is a short list ; while even if we include what may be called minor contributors—the workers out of small details and slight improvements—the list, although extended, represents a tiny and negligible fraction of the great hosts of people of many races who have lived in the world during its recorded history.

If, for example, we take the discovery of the power of steam and its practical application to industry, a score of names covers the main contributors, and a list of a few thousand names covers every important invention connected with the subject. If, again, we consider electricity and its practical use, the same truth becomes evident. A few men of outstanding genius, a few hundred men of great cleverness, a few thousand men of considerable but minor ability, have given the world the control of electrical power. If we put steam and electricity together and make a list of names, we realise that the number of men who gave us these wonderful and invaluable powers is so insignificant a fraction of the thousands of millions of people who lived in their time that a few unhappy accidents might have made the leaders the victims of disease or injury, and kept the world as a whole waiting a much longer period for the great engineering inventions.

The modern civilised man is often tempted to regard himself as a clever creature, because he enjoys the fruit of other men's genius. He is apt to despise what he calls the lower races of mankind, because they have not in constant use the engines, machinery, and appliances which are commonplaces in a white civilisation. The hard fact of the matter is, however, that the great majority of the inhabitants of a European nation have no more knowledge of the great inventions, and are entitled to no more credit for the great inventions, than the most ignorant savage who lives at this hour in the interior of Africa or South America.

In London, for example, there are hundreds of thousands of users of the telephone, but probably not more than two or three in each thousand, if as many, could take pen and paper and explain in clear English, with or without the aid of a few simple diagrams, how the sounds spoken into a mouthpiece in the City of London are transmitted to a receiver at Whitechapel or Westminster. This is to name only one illustration out of thousands that might be given to remind the reader that most civilised men are still content to enjoy that which they do not understand. Perhaps no more striking instance could be named than the kinematograph. It is probable that not one in ten thousand of those who on any evening are witnessing a kinematograph entertainment could explain why their eyes perceive a moving picture, or upon what quality of sight—or, rather, upon what defect of sight—the illusion of a moving picture is founded.

It is, therefore, not only true that a comparatively few men have given wealth to the world, but that, even after the few great men have done their work, the multitude of people have not even much curiosity with regard to the inventions by which they benefit.

It is a great misfortune for the masses of the people that such a position should obtain. Apart from the desirability of

enlisting the mental powers of all men in the furtherance of intelligent work, it is an unhappy thing that so many people should remain ignorant of the science which underlies modern work. It is a misfortune because unless the masses of the people understand the means with which the world has been dowered by the ability of a few, those means will not come to be so well employed in the common service as would be the case if an intelligent public opinion, inspired by knowledge, insisted upon the full application of acquired powers.

Take, for example, the main principles and possibilities of town-planning and town-making. The great majority of people are content to live under conditions which are obsolete and unworthy of a scientific age. They are content to pay a considerable proportion of their incomes as rents for homes which are as inconvenient as they are ugly and unhealthy. It has not yet been realised by the great majority that such things as light and air, trees and flowers, beautiful architecture and healthy recreation, can be freely enjoyed by modern town populations as soon as they make up their minds to employ well-known means to obtain them. It is not that we still lack the power to create noble and beautiful cities; it is simply that people are not yet educated in the conception that they are *neglecting what has been discovered*, and actually frustrating the operation and application of great ideas which might change the whole course of their lives.

Let us return to the point that the ideas which underlie wealth production are the gift to the world of a few people. If we realise this, we see plainly that it is our duty to *sow* ideas. No man deserves to escape reproach who does not seek to sow and cultivate, for the sake of the future, the ideas of better men than himself.

If there is a man among us—and it is to be feared that such men are legion—who has not read his Shakespeare to such effect that the thought, the imagery, and the language of Shakespeare have become part of his life, then for him Shakespeare has never lived. If there is a man who has not grounded himself in physical science, then for him the earth, the solar system, the starry heavens, the various manifestations of motion, have either no meaning or a perverted meaning, in spite of the vast and fascinating stores of systematised knowledge which have been accumulated during the last century.

And it is not merely that a nation which desires the greatest degree of success in breeding ideas must seek to educate all its people to the full realisation of their individual powers as applied to the world's stock of knowledge. In our attempts to make wealth-producing ideas fructify, we have, if we can, to arrive at the best means of cultivation. It is one thing for people to know how to do things; it is another thing for them to agree with each other how the knowledge should be applied. When we speak here of the breeding of ideas we are speaking not of the production of new ideas, but of the propagation of existing ideas.

The scientific observer of our society, our industries, and our institutions complains not so much of the lack of new ideas—although, of course, it is a most desirable thing to increase the common stock of ideas—as of the want of application of existing ones. It is an undoubted fact that if we imagined discovery and invention to come to an absolute close at this hour, we already possess such a stock of knowledge that we have the means to produce a sufficiency of the comforts and even of the luxuries of life for all our population. If, therefore, so many people lack comforts, and even necessaries, it is because our existing ideas are not sufficiently bred and multiplied.

Let us take as illustration any common article necessary to the comfort of a civilised life—say, a bathroom, containing sanitary and convenient bathing and washing appliances in the shape of a bath and a lavatory basin furnished with a constant supply of hot and cold water. In essence this bathroom is a small collection of clever but not particularly brilliant ideas, which, although, not great, are mightily conducive to health and happiness. We are at once faced with the really remarkable fact that of the nine million private-dwelling houses of the United Kingdom there are not three hundred thousand, if as many, which possess good bathrooms adequately fitted.

Here, therefore, we have a case in which some rather ordinary ideas are bred so insufficiently that the great majority of our people have to go without one of the major comforts of civilised life, and that although bathing on a most refined scale was well understood and practised in this country

two thousand years ago by the Romans, traces of whose remarkable appliances may yet be found in the United Kingdom.

Or take another matter as to which in a climate like ours we need to make a good and sufficient provision if we are to have common comfort. We have a long and usually damp winter, but fortunately we have one of the finest supplies of coal in the world. In these circumstances a messenger from Mars might imagine that on arriving on the Earth and examining the United Kingdom he would find that an intelligent white people had most surely attended sufficiently to the all-important matter of making their homes comfortably warm during the long winter-time.

Alas! the facts show that, possessing coal, we use it so badly that it is only a small minority of the homes of our country which are kept comfortably and healthily warmed in cold weather. It is doubtful, indeed, whether there are as many as two hundred thousand houses among our nine million houses where any attempt is made to warm the bedrooms, and even where this attempt is made it is by the clumsiest means imaginable. Given the application of well-known and easily understood methods, every house in the country might be made comfortable in the winter by a comparatively small expenditure of the national fuel supply. Again it is a question not of lack of ideas, but of the lack of breeding of ideas. The seed exists, but it is rarely and badly sown and poorly cultivated, and therefore the harvest of practical comfort is a poor one.

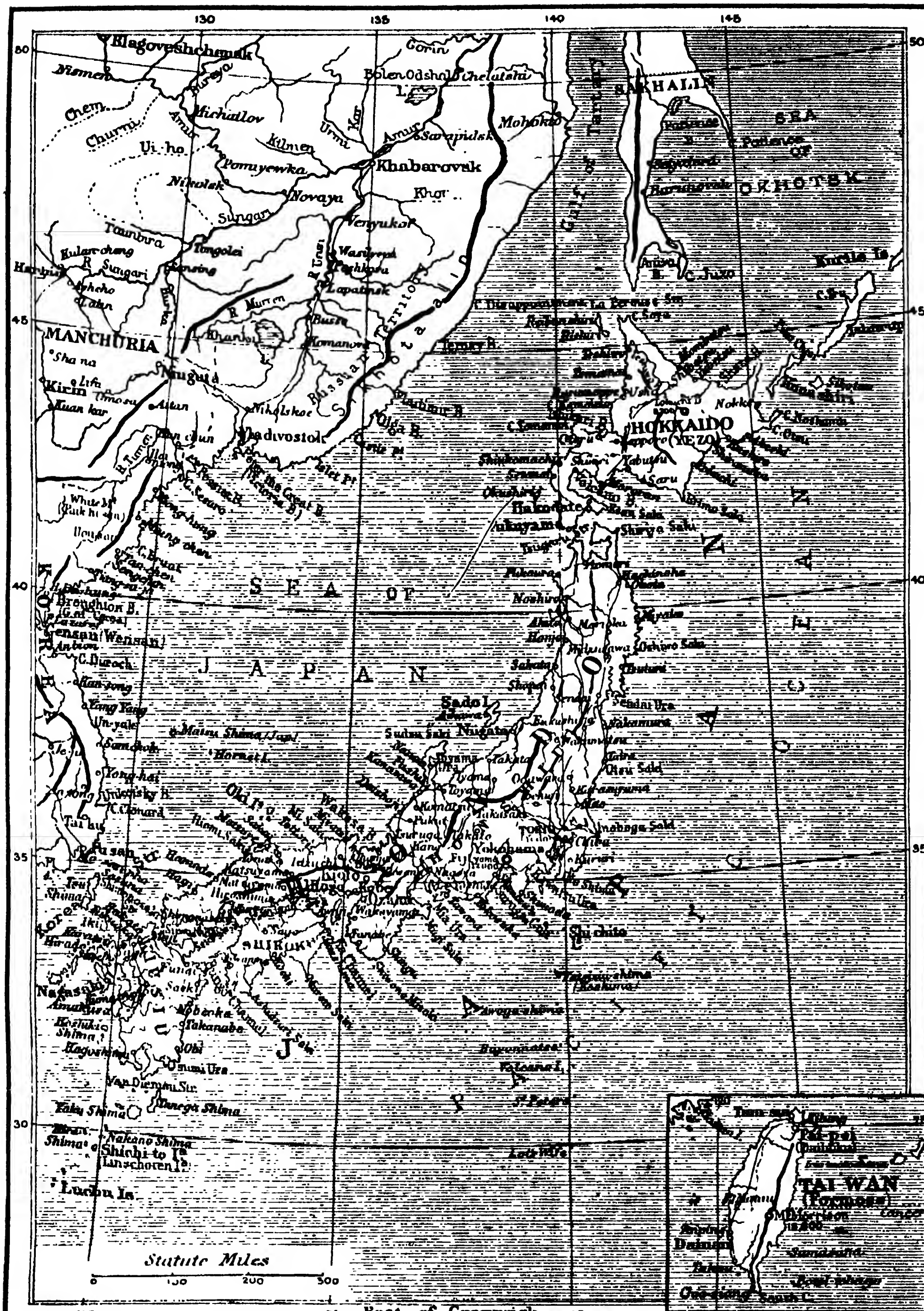
The facts as to the slow breeding of ideas are the more remarkable because everybody has the right to sow them. There is no property in ideas, or, to speak quite accurately, the Governments of all modern States give an inventor an exceedingly short monopoly. The United Kingdom, for example, by its Patent Law limits the duration of a patent of monopoly to fourteen years, unless it appears that the patentee during the fourteen years has been inadequately remunerated for his invention, in which case the Courts may extend the term of the patent of monopoly for a further term of seven years, or, in an exceptional case, for a further fourteen years.

No matter how wonderful an invention may be, no matter how much new wealth it may produce, the inventor, we see, is only allowed a monopoly of the fruit of his wonderful idea for a term of from fourteen to twenty-eight years. It follows, therefore, that nearly every patent existing at this moment will have lapsed in fourteen years from this time, and, of course, as to the great mass of good inventions, the patents expired long ago. Let us remind ourselves further that the ideas at our disposal are not only British ones, but foreign ones as well. Our heritage of knowledge is not that of a nation, but that of a world of many nations. All the creative powers of the various races of men have been lavished upon us, who are the inheritors of all the ages.

In these circumstances, to neglect the proper and adequate breeding of ideas is criminal folly, and it is a folly for which we have to pay dearly in the disorders and disharmonies which detract from our enjoyment of the world, and which present us in our social institutions with so many grave problems. The sociologist is often tempted to believe that by moulding social institutions he can do all that is needed to abolish poverty and destitution—to produce a more worthy civilisation. The sociologist, however, must work hand in hand with the expositors of all the sciences if he is to achieve his aims. The powers of science and government need co-ordination, and the statesman, in framing his plans, must endeavour to give free play to what we have described as the breeding of ideas

We might go farther still and say that it is the first duty of the statesman to further, to promote, to stimulate, the sowing and harvesting of ideas by direct action. It is not enough to relegate wealth production to blind chance, and to the haphazard enterprise of individuals who may or may not do their duty. A modern people, educated in the knowledge of its heritage of power, must constantly survey its resources and its development; and wherever it finds a lack of the full application of creative knowledge it must insist upon the gap being filled. If it does not do that, then the world's geniuses have laboured in vain. The work of the few may be made work done for all, but there will never be sufficient application to all of the ideas of the few until knowledge of those ideas and the determination to apply that knowledge have become a common possession and a common aim.

L. G. CHIOZZA MONEY



THE EMPIRE OF JAPAN

Japanese Islands. Build of the Country. Fujiyama. The Philippines. Successful Agriculture, Fisheries, Minerals, and Manufactures. Korea. Malay Archipelago.

THE JAPANESE EMPIRE

The Japanese Empire. The Japanese Empire (261,000 sq. miles) consists of five large and 600 small islands, forming a double festoon from Kamchatka to Southern China. The chief groups and islands are (1) the barren Kurile Islands; (2) Hokkaido or Yezo, the most northerly of the larger islands, separated by a narrow strait from (3) Hondo or Honshiu, the largest island, off which lie (4) Shikoku and (5) Kiushiu; (6) the long Luchu group connects the islands named, which form Japan proper, with (7) Formosa (1895), (8) Southern Sakhalin (Karafuto) (1905), and (9) Korea (1910).

The Japanese Empire stretches from the latitude of Northern France to south of the Tropic of Cancer, and varies in climate from temperate to tropical, modified somewhat by oceanic conditions. All the larger islands lie in the monsoon area, and have abundant rains.

Japan. Japan proper is everywhere mountainous, and large plains are rare. The island lies on one of the great world-lines of volcanic activity, and volcanoes, active and extinct, are numerous. Of many extinct cones, the most perfect is Fujiyama, the sacred mountain of Japan (12,000 ft.). Owing to the abundant rainfall, dense forests cover three-fifths of the area. With the world's demand for timber rapidly increasing, as the supply decreases, this is a valuable national asset, and the Japanese wisely pay great attention to scientific forestry. The rivers are numerous, but short. Though too swift for navigation, they serve to float down timber, to irrigate the cultivated lowlands, and to generate power.

Among the forest trees are the sago plant and bamboo, both found as far north as Tokyo, the lacquer tree and the camphor laurel. Familiar trees are the pine, elm, chestnut, and beech. A beautiful tree is the cryptomeria, a stately cedar. Flowering shrubs are everywhere, for Japan, even more than China, is a flowery land.

Fujiyama. No one can think of Japan without thinking of Fujiyama, or Fujisan, which figures in every Japanese picture. "Living at Tokyo," wrote Sir Edwin Arnold, "or Yokohama,' or anywhere along the Tokaido, the southern road of Japan, you would soon see how the great volcano dominates the landscape and becomes an indisputable element in the national scenery. Far away at sea, when approaching Japan, long before the faintest blue line of coast is discernible, there is seen hanging in the air a great white symmetrical cone. That is Fuji. After you have landed, you will always be seeing Fuji from some garden, some tea-house gallery, some grove of cryptomeria, or thicket of bamboo. There are loftier peaks, of course, but there is none which rises so proudly alone from the very brink of the sea.

"It is a circuit of 120 miles to go all round the base. The lower portion is cultivated to a height of 1500 ft., and it is a whole province which thus climbs round her. From the border of the farms begins a rough and wild but flowery woodland, which stretches to 4000 ft., where the thick forest belt begins. Above the forest extends a narrow zone of dwarfed larch and juniper, after which comes the bare, burnt, and terribly majestic peak itself." In winter the snows extend half down the mountain's colossal sides, adding the last touch to its beauty.

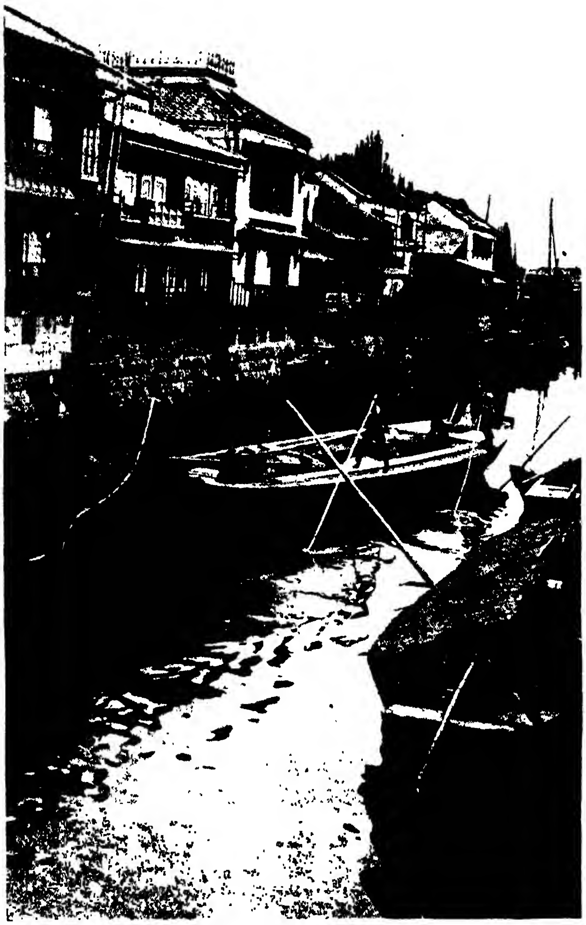
Japanese Agriculture. The lowlands of Japan are only one-fourth of its area, and only one-sixth of the islands is cultivated. Nevertheless, the population is very dense, and agriculture is the chief occupation. Many causes account for its success. The first is the laborious industry of the people, who practise spade cultivation and till their farms with the care of gardeners. Secondly, no fertilising matter is wasted in sewage, so that manure is abundant. The third cause is the prolific nature of the staple crop—rice. All rice-lands are densely peopled. The fourth cause is the frugal habits of the people, who can subsist on a scanty diet of rice and fish. These causes have hitherto enabled Japan to support her large population at home, but the pressure is now beginning to be felt, and the Japanese, like the Chinese, seem destined to colonise extensively around the shores of the Pacific. Owing to the value of land for agriculture, live-stock has never been important in Japan, though horses are now being bred for military purposes.

Japanese Crops. Rice is the staple cereal, with wheat as a winter crop. Barley and beans are largely grown. Most farmers breed silkworms. Mulberries are planted in rows between the crops, to which they give shade. Tea is the second staple. It grows well south of Tokyo, and is found wild on the hills of Kiushiu, Shikoku, and Formosa. Native cotton is very short in fibre; American cotton has been introduced, but the demand of the cotton-mills is not yet met. Tobacco is a Government monopoly. Fruit is grown for export; the cherry and plum have been planted from time immemorial for the beauty of their blossoms.

Fisheries. The seas around Japan swarm with fish, and the shores are everywhere indented with good harbours, while the wooded hills surrounding them provide timber for boat-building. Nearly 1,000,000 families are employed in fishing, and fish is a staple of Japanese diet.

Minerals and Manufactures. Coal is found chiefly in Hokkaido and Kiushiu. Iron is abundant, but is not found near coal. Petroleum is widely distributed, and Japanese copper is of very fine quality. The arts of Old Japan were no less exquisite than those of India, including wonderful lacquer work, porcelain, cloisonné, and other decorative metal industries, painting, and embroidery. Within the last fifty years the industries of the west have developed rapidly. The hideous mill-chimney is now a common sight in the exquisite Japanese landscape. With their frugal needs and extraordinary technical skill, the Japanese will soon become powerful rivals in the markets of the world. Ozaka, on the Inland Sea, is the Manchester of Japan.

Japanese Towns. Hakodate, in Hokkaido, near rich coalfields, is the outlet for the resources of that island. In Honshiu, the capital is Tokyo, with many industries, including shipbuilding and chemical and engineering works. The port is Yokohama, at the entrance to Tokyo Bay, with an enormous trade. Farther south is Nagoya, the largest town on the Tokaido line, which connects Tokyo with Kyoto, the ancient capital situated near Lake Biwa, the largest lake in Japan. A few miles distant is Ozaka. The chief port of Southern Honshiu is Kobe, on the Inland Sea. In Shikoku, Tokushima is a flourishing town. The commercial centre of Kiushiu is Nagasaki, a fine harbour, near rich coalfields.



A BUSY CANAL IN TOKYO

Korea. The Korean peninsula (82,000 sq. miles) is everywhere rugged, the northern mountains rising to 8000 ft. The fertile valleys produce cotton, hemp, and tobacco. The capital is Seoul, on the Han, the longest river, at the mouth of which is the chief port, Chemulpo, on the west coast. Fusan, on the Strait of Korea, has a large trade with Japan.

Formosa. Formosa is mountainous in the east, where the cliffs rise sheer 6000 ft. from the Pacific. The mountains are densely forested, and inhabited by wild head-hunting tribes. Camphor is the chief product of this region. The western half is a lowland with good harbours facing China. The Chinese form a large element in the population, cultivating sugar, rice, tea, indigo, fibre plants, and the like.

The Philippine Islands. This archipelago, including 1200 islands (128,000 sq. miles), the largest of which is Luzon, belongs to the United States. All are mountainous, volcanic, densely forested, well watered, and extremely fertile. Tobacco and Manila hemp are the most valuable products. Many of the varied tribes are at a low level of civilisation. The capital is Manila, on Luzon.

The Malay Archipelago. Of the innumerable islands which form this archipelago (783,000 sq. miles), the largest are Borneo, Sumatra, Java, and Celebes, all Dutch except part of Borneo; all are very mountainous and volcanic.

The climate is tropical. The equatorial belt has rain all the year round, but outside this belt the wet and dry seasons are well marked. The forests produce rubber and other useful substances, which are collected by natives. Borneo, the largest island, is as yet little developed. British Borneo, in the north, grows tobacco, coffee, and pepper. Dutch Borneo exports tobacco, pepper, sugar, rubber, and other forest produce, edible birds' nests, *bêche de mer*, or sea-slugs, a Chinese delicacy, and tortoise-shell. Java, with fertile volcanic soil, produces coffee, sugar, tea, indigo, cacao, tobacco, spices, rice, and sago. The capital is Batavia, the great emporium of trade in the archipelago. The products of Sumatra and Celebes are very similar. The Molucca Islands, between Celebes and New Guinea, produce cloves and other spices.

A. J. AND F. D. HERBERTSON

Hexagonal and Octagonal Prisms. The Ring. Circles touching lines and circles. Foiled figures.

OBJECT DRAWING AND GEOMETRY

For further practice in training the eye, and to show how to analyse an object to find a simple system of construction for drawing it correctly, we will now explain the geometrical models called the hexagonal and octagonal prisms.

The Hexagonal Prism. This object has a regular hexagon for each of its ends, and oblong for each of its other surfaces, but both shapes will, of course, vary infinitely *in appearance* according to the point of view from which they are seen. In **217** (which is the appearance of the prism when the student is directly opposite the end, but the object below the eye level), a system of construction lines (dotted), will be noticed—viz., *AD*, which is parallel to *BC* and *EF*; also *BF* and *CE*, *vertical* lines through *B*, *F*, and *C*, *E*, respectively. If *GH* is bisected in *K*, it will be seen that there are *four equal parts* along *AD*—viz., *AG*, *GK*, *KH*, and *HD*. These, of course, will not appear equal when the object is placed in such positions as represented in **218–224**.

A view as shown in **218** is a good one from which to learn the method of drawing this object. Begin by determining the position of the corner *C* with relation to surrounding objects, then the direction of apparent slant of the edges *BC* and *Cc* and their respective apparent lengths. From *B*, *C*, and *c* draw vertical lines *BF*, *CE*, and *ce*, and determine the relative height of *CE*. Through *E* draw *Ee* converging with *Cc*, and *EF* with *CB*. Bisect *CE* in *H*, and *BF* in *G*. Through *G* and *H* draw *AD* converging with both *CB* and *EF*. Fix the position of *K* by drawing the diagonal *BE*. Make *HD* slightly—very slightly—longer than *KH*, and *AG* very slightly shorter than *GK*. The student should consider carefully why these are apparently different lengths, although in the object really the same.

Join *AB*, *CD*, *DE*, and *FA*, which will complete the apparent shape of the nearer end of the prism. Through *D*, *E*, and *F* draw lines converging with *Cc*. The line *Ee* intersecting with *ce* determines the height of *ce*. Through c draw *dc* converging *downwards* with *DC*, and through *e* draw *de* converging *upwards* with *DE*, and *ef* converging with *EF*, thus completing the drawing. The dotted lines at the further end are put in to show the full construction, and that again we have an instance of the further end being *apparently* slightly wider from *a* to *d* than from *A* to *D* at nearer end, but of course (owing to the convergence of *Ee* with *Cc*) the length of *ce* is shorter than *CE*. The foregoing method is somewhat mechanical, but if the student will make careful observation from the model he will find the method an excellent proof of the accuracy, or otherwise, of his capacity of judging apparent lengths, etc., or of guiding or even compelling him to see the true apparent sizes, etc., of the object.

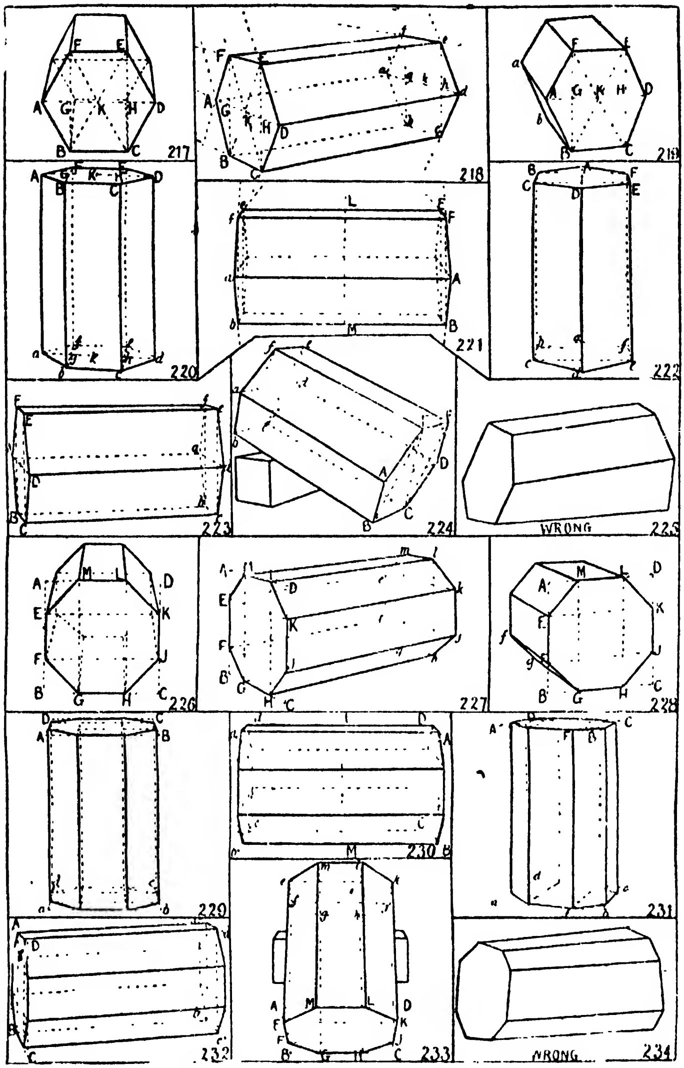
In **218** it should be observed that there are *four* directions of convergence: first *Cc*, *Dd*, *Ee*, and *Ff* converging to the right; second, *CB*, *DA*, *EF*, and *ef* to the left; third, *DC*, *FA*, and *dc* downwards to the left; and fourth, *DE*, *BA*, and *de* upwards to the left. Compare **218** with **225**, which is an incorrect drawing of the same view, showing the many usual errors made by beginners. Intelligent consideration should be given to *why* **225** is wrong in so many respects. The student should place the object as indicated in **218**, and make careful tests.

In **220** and **222** notice how *BA*, *DE*, and *ab* converge with one another; also *AF* with *CD* and *cd*; and *CB* with *EF* and *cb*. Fig. **221** shows the representation when the observer is directly opposite the dotted line *LM* and the object below the eye level. Notice the *three* sets of converging lines, and that *AB* is apparently smaller than *AF*, and *FE* much smaller still. In **219** observe the peculiar apparent shape of the face *ABba*. A view like that shown in **223** often gives considerable difficulty to beginners, owing to very much foreshortening of the visible end, but it is constructed just like **218**. Fig. **224** is also rather difficult, because of the tilting of the object, but keen observation of the model will enable the student to overcome such difficulties. Notice that the corners *E* and *F* are not *vertically* above *B* and *C* respectively, and that the construction lines *FB*, *EC*, *fb*, and *ec*, converge *downwards*. There are also, as in **218**, *four* directions of convergence.

The Octagonal Prism. This model has a regular octagon at each end, but oblongs for each of its other surfaces, and both shapes may have an infinite number of appearances from different points of view. Fig. **226** is an end view, and shows how the regular octagon may be enclosed in a square *ABCD*. Then, if the relative sizes of *BG* and *GH* are determined, the construction is easily made, for *AE*, *AM*, *BF*, *BG*, *CH*, *CJ*, *DK*, and *DL* are all equal in this view. Draw the construction lines as indicated.

Fig. **227** gives the usual system of guide lines. First determine the position and distance apart of the vertical lines *AB* and *CD*, and obtain the apparent height of *CD*. Draw *CB* and *DA* converging at the correct angle towards the left, thus completing the *apparent shape* of the skeleton square *ABCD*. Then by careful comparison fix the positions of the points *G*, *H*, *J*, and *K*, and through each draw the respective construction lines, which at certain intersections give the positions of the corners of the octagon's *apparent shape*. Join these corners by the lines as shown. The completion of the drawing needs only care in observation as regards proportion and convergence of certain edges. Fig. **227** should be compared with the *incorrect* drawing shown in **234**, which contains very many errors, usually made by careless observers. By intelligently criticising a bad drawing, and finding out why it is wrong, a student may sometimes learn more about the correct way it should be drawn than if he merely looked at a true representation of it; and, moreover, certain principles will be more deeply impressed upon his mind by this method.

There is no need to give detailed explanations of the other representations of the octagonal prism as shown in **228–233**, as the drawings, with the dotted construction lines, speak for themselves as



217–234. A LESSON IN THE HEXAGONAL AND OCTAGONAL PRISMS

regards the method to be used in obtaining the various apparent shapes. The student must place the prism as indicated and draw *from the object.* Fig. **229** is the appearance when the student is opposite the front face, but the object below the eye level. Fig. **230** gives the representation when viewed from a point opposite the line *LM*. Fig. **231** shows how the drawing should be made when seen from a point practically opposite the edge *Ff*. Fig. **232** shows the drawing of the difficult view when the near end is much foreshortened, while **233** is perhaps more difficult still, as the object is tilted upwards directly away from the observer, and particular attention should be given to the foreshortening of the near end, as well as the correct direction of convergence of certain edges.

Application of the Principles in this Lesso.n It is sometimes difficult to obtain objects which are hexagonal or octagonal in shape, but drawings are given in **235-237**, **239**, and **240**. The objects should, in some cases, be placed lying over on their sides, so as to give further practice in drawing difficult views, and to give opportunities for improving the powers of observation to a higher level of excellence.

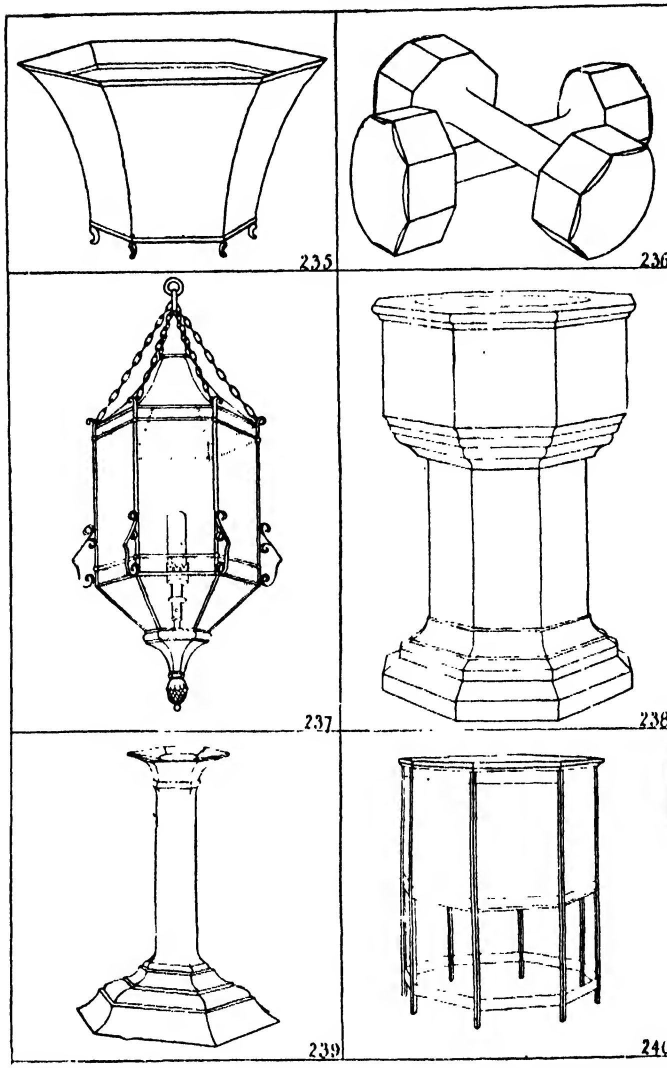
The Ring. Our model for the following lesson is the ring, which well illustrates two important principles to be observed :

1. That although the rim of an object, such as that of a cup, vase, wheel, etc., may be the same thickness all round, yet it will not necessarily appear so.
2. How the wheels of vehicles, machinery, etc., should be drawn, as regards not merely the apparently varying thickness, but the apparent *direction* of their major axes.

Horizontal Positions of the Ring. Figures **241** and **242** indicate how the construction should be made when the ring is lying in a horizontal plane. The first difficulty is with regard to the *direction* of the major axis, and when determining this the student should not be misled by the apparent direction of the edges of surrounding objects, such as the edges of, say, a board, box, table, etc. *Whatever the apparent direction of the latter may be, the major axis of the ring or wheel will always appear horizontal when the ring is lying in a horizontal plane.* This should be verified by the student, by placing the ring on a flat table or board, so that the edges of the latter are receding from him in various directions, as in **247** and **248**. Therefore, begin the construction by drawing a horizontal line *AB* for the major axis of the top outer ellipse, carefully observing how high or how low it should be with regard to neighbouring objects.

When the length of *AB* has been fixed, bisect the axis in the point *C*, and through *C* draw the minor axis *DE* at right angles to *AB*. Then find out the apparent length of this minor axis compared with *AB*, and through the four points *A*, *B*, *D*, and *E* draw the curve of the ellipse, which represents the outer top edge of the ring. Now we come to the most important principle to be observed concerning this and similar objects, and that is, *although the top inner edge is really parallel with the outer edge, it does not appear so.* By careful observation of the model it will be seen that the ring *appears considerably wider at AF and JB towards the ends of the major axis* than it does at *EG* and *DH*, the ends of the minor axis. The student should now make further experiments with cups, vases, jars, and similar objects, and he will find that there is generally an apparently wider thickness at the ends of the major axis than at the ends of the minor axis. More illustrations bearing on this

point will be given later when dealing with vases of various shapes. Thus it will be seen how important it is to determine the apparent thickness at AF, BJ, EG, and DH very accurately. It should be noted that the major axis of the inner ellipse does not quite coincide with that of the outer ellipse, but is very slightly above. The further top thickness, DH, is also apparently slightly less than the nearer top thickness EG. Then draw the inner ellipse through the four points F, G, J, and H. Now find out the apparent upright thickness EK, which is *practically about the same* as AF or JB, but *theoretically a little larger*, because EK is slightly nearer than AF or JB, but the difference is scarcely appreciable, unless the ring is very large. The lower outside edge, it must be remembered, is part of another ellipse vertically under the top outer one, which was drawn first. In **241** and **242** the construction shows the invisible portion by dotted lines. There is yet another curve, the lower and inner edge, which is but little seen in **241**, but better in **242**. This curve is also part of an ellipse, as shown in **241** and **242**, which will explain better than words what the curve appears like, and its relation with the upper and inner ellipse.



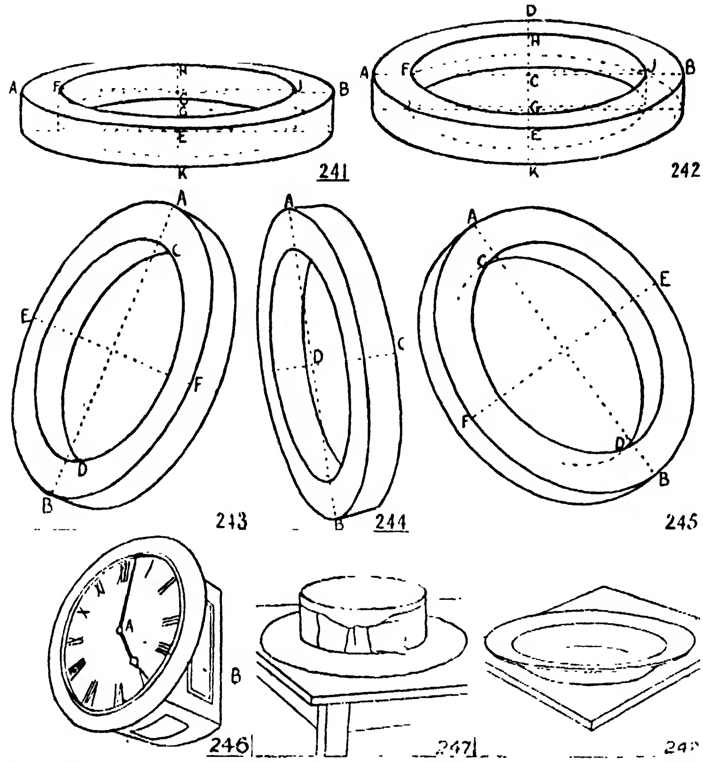
235–240. OBJECTS DRAWN ON THE SAME PRINCIPLES AS THE HEXAGONAL AND OCTAGONAL PRISMS

Oblique Positions of the Ring. Figures **243** and **245** are representations of the ring in a leaning or slanting position. When beginners attempt to draw such views they generally make a very bad mistake about the *direction* of the major axis AB, because they do not use their eyes properly, and do not know the very good guide that, if the pencil is held so that it apparently passes through the two points C and D—the apparent intersections of the upper and lower inner edges—the major axis appears to be in *the same direction*, but not exactly in the same *position*, for the major axis is practically midway between the point E on the further side, and F on the nearer part of the outer edge. *The above guide holds good when the ring is in any position whatever* [see **241** to **245**]. After the direction, position, and length of the major axis are determined, the construction is the same in method as in **241** and **242**. The student should remember and *see* that the major and minor axes are always at right angles to each other, as this is a very important point indeed.

Vertical Position of the Ring. Figure **244** is an interesting and important view, supposing the ring to be below the eye level, and standing in a *vertical* plane, as the wheels of a cart or carriage might be. Here, again, beginners make errors, because they think the major axis must be upright since the ring is upright, *but it is not necessarily so*; in fact, the axis can only appear *vertical* when the centre of the ring is exactly on a level with the eye of the observer.

The above statement should be compared with what was explained about the cylinder in the position shown in **148**, and the student will find that the law is really the same, for the ring may be considered as a hollow cylinder with its axis receding to the right in **244** in the direction DC; therefore, the major axis AB must be drawn at right angles to DC—the axis of the object.

Application of Above Principles. See how the foregoing principle is applied in the drawing of the clock in **246**, where an imaginary line through I. and VII. for the major axis of the dial is at right angles to AB, the axis of the clock, although the face is really in a vertical plane. The clock, for the purposes of this drawing, is assumed to be above the eye level.



241–248. A LESSON ON THE RING AND OBJECTS SIMILAR IN CONSTRUCTION

Again, in **249** the major axes of the two wheels are both at right angles to the axle of the cart. Thus, the longest direction of the wheels is apparently slanting, and yet the wheels are upright in reality. Further attention should be given to the width of the rim of the front of the clock in **246**; the hat brim in **247**; the rim of the plate in **248**; and the widths *AB* and *CD* (at the ends of the major axes) of the rim of the wheels in **249**, which are wider than *EF* and *GH* at the ends of the minor axes.

Rules and the Perceptive Faculties. It is necessary that students should not merely draw by rule, but they should endeavour to so train their perceptive faculties that, after a time, they may be able to see intuitively—nay, almost without effort—the varying changes in the appearance of an object. Rules, if correctly remembered, will give much guidance with regard to *how to see*. There are, unfortunately, many students who retain only a vague notion, or even, perhaps, a distortion or transformation, of some rule which has been explained to them, and then, of course, the rules are worse than useless. Therefore, try to remember rules correctly, and, as well, do all you can, by practising drawing, to improve the hand in skill and the eye in seeing aright.

GEOMETRY

The problems in this part depend for their solution upon the following truths in Euclid.

i. If a straight line be a tangent to a circle, and from the point of contact a line be drawn perpendicular to the tangent, the centre of the circle shall be in that line (Euc. III., 19).

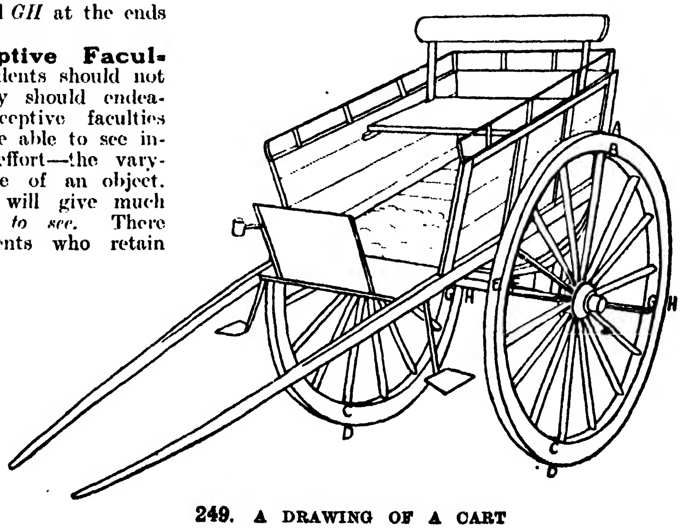
ii. If one circle touch another internally in any point, the straight line which joins their centres being produced shall pass through the point of contact (Euc. III., 11).

iii. If two circles touch each other externally in any point, the straight line which joins their centres shall pass through that point of contact (Euc. III., 12).

250. To Inscribe a Circle in a Given Triangle *ABC*. Bisect any two angles *ABC* and *BCA* by lines intersecting at *D*. From *D* draw *DE* perpendicular to either of the sides of the triangle, then *DE* is the radius and *D* the centre of the required circle.

251. In a Given Equilateral Triangle *ABC*, to Inscribe Three Equal Circles, Each to Touch One Side and Two Circles. Bisect the angles by lines which also bisect the sides in *D*, *E*, and *F*, and intersect at *G*. Inscribe a circle in the triangle *GBC* (Prob. **250**). Mark off *GJ* and *GK*, each equal to *GH*, then *J* and *K* are the centres of the other circles.

252. In a Given Square *ABCD*, to Inscribe Four Equal Circles, Each to Touch One Side and Two Circles. Draw the diagonals and the diameters intersecting at *E*. Inscribe a circle in the



249. A DRAWING OF A CART

triangle *EBC* (Prob. **250**). With centre *E* and radius *EF* mark off *EG*, *EH*, *EJ*, each equal to *EF*, then *G*, *H*, and *J* are the centres of the other circles.

253. In any Given Regular Polygon (say, *ABCDEF*), to Inscribe as Many Equal Circles as the Figure has Sides, Each Circle Touching One Side and Two Circles. Divide the figure into equal triangles, and inscribe a circle in each, as shown.

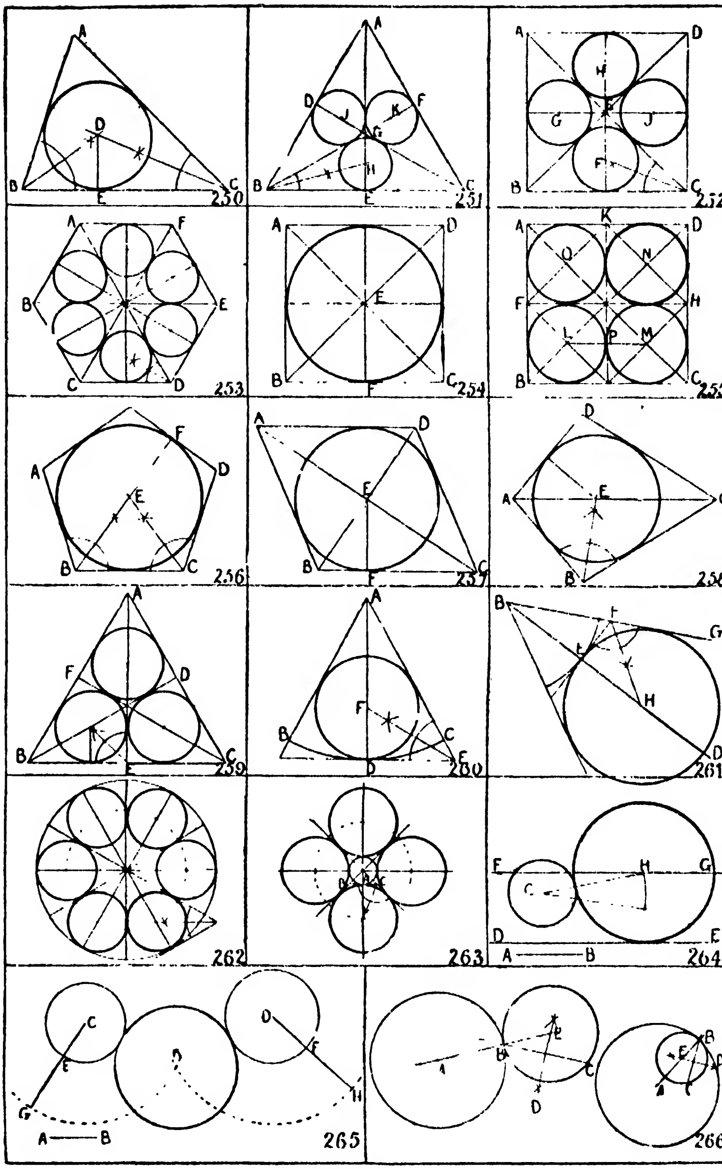
254. To Inscribe a Circle in a Given Square *ABCD*. Draw the diagonals and diameters to find the centre *E*, and with radius *EF* describe the circle.

255. Within a Given Square *ABCD*, to Inscribe Four Equal Circles, Each Touching Two Sides and Two Circles. Draw diagonals and diameters as before. Join *F*, *G*, *H*, and *K*. The intersections *L*, *M*, *N*, *O*, with the diagonals, are the centres of the circles. Join *L* and *M*, then *LP* or *MP* is the radius required.

256. To Inscribe a Circle in any Regular Polygon. Bisect any two angles *ABC* and *BCD*, then *E* is the centre, and a perpendicular (say, *EF*) from *E* to either of the sides is the radius.

257. To Inscribe a Circle in a Given Rhombus *ABCD*. Draw the diagonals to find the centre *E*, and a perpendicular (say, *EF*), from *E* to either of the sides is the radius.

258. To Inscribe a Circle in a Given Trapezium *ABCD* Draw the diagonal *AC* and bisect one of the other angles, then *E* is the centre, and the radius is a perpendicular to either of the sides.



CIRCLES TOUCHING LINES AND CIRCLES

259. Within a Given Equilateral Triangle *ABC*, to Inscribe Three Equal Circles, Each Touching Two Sides and Two Circles. Bisect each of the angles by the lines *AE*, *BD*, and *CF*, thus obtaining three equal trapeziums, in each of which inscribe a circle as in **258**.

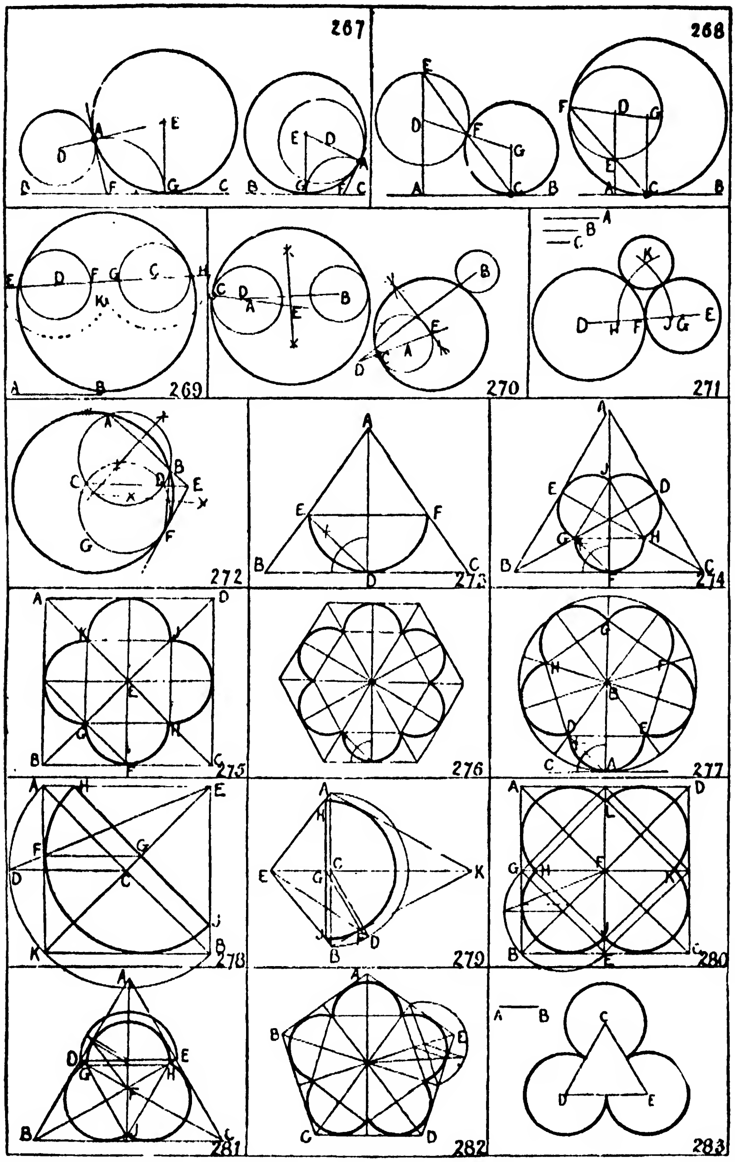
260. To Inscribe a Circle in a Given Sector *ABC*. Bisect the angle by *AD*. Through *D* draw a tangent *DE* to meet either *AB* or *AC* produced in *E*. Bisect the angle *AED* by the line *EF* intersecting *AD* at *F*, which is the centre, and *FD* the radius of the required circle.

261. To Describe a Circle to Touch the Arc of a Sector and the Two Radii Produced. Bisect the angle by *BD* intersecting the arc at *E*. Through *E* draw the tangent *EF*. Bisect the angle *EFG* by the line *FH* intersecting *BD* in *H*, which is the centre, and *HE* the radius of the circle.

262. To Inscribe any Number of Circles in a Given Circle. Divide the circle into twice as many sectors as circles required, and inscribe a circle in each sector (Prob. **260**). The centres are found as shown by the dotted circle.

263. To Describe any Number (say, Four) of Equal Circles about a Given Circle. Divide the circle as in **262** and produce the diameters. At the point *A* draw a tangent *BC*. Then proceed as in **261**. The other centres are found as shown by the dotted circle.

264. To Describe a Circle of a Given Radius *AB* to Touch a Given Circle *C* and a Given



267–283. CIRCLES TOUCHING LINES AND CIRCLES. FOILED FIGURES

LINE *DE*. Draw *FG* parallel to *DE* at a distance equal to *AB* from it. With centre *C* and radius equal to the sum of the radius of circle *C*, plus *AB*, describe an arc cutting *FG* in *H* which is the centre required.

265. TO DESCRIBE A CIRCLE OF A GIVEN RADIUS, TOUCHING TWO GIVEN CIRCLES EXTERNALLY. Let *AB* be the given radius. Find the centres *C* and *D* of the given circles, draw radii *CE* and *DF* and produce them. Set off *EG*, *FH* equal to *AB*. With centre *C* and radius *CG* describe an arc. With centre *D* and radius *DH*, intersect in *K*. With centre *K* and radius *AB* describe the circle. If the arcs were continued, the centre for another circle would be obtained at their upper intersection.

266. TO DESCRIBE A CIRCLE TO TOUCH A GIVEN CIRCLE *A* IN A GIVEN POINT *B*, AND TO PASS THROUGH A GIVEN POINT *C*, EITHER WITHIN OR WITHOUT THE CIRCLE. Join *B* and *C*. Bisect *BC* by a perpendicular *DE*. Join *B* and *A*, and produce *BA* to meet *DE* in *E*, which is the centre, and *BE* the radius of the circle required.

267. TO DESCRIBE A CIRCLE TO TOUCH A GIVEN CIRCLE AT A GIVEN POINT *A*, AND A STRAIGHT LINE *BC*. *First externally:* Find *D*, the centre of the given circle, and draw *DE* through *A*. At *A* draw the tangent *AF* meeting *BC* in *F*. With *F* as centre and *FA* as radius describe an arc cutting *BC* in *G*. At *G* erect a perpendicular to *BC* intersecting *DE* in *E*, which is the centre. *Second, including the given circle:* Draw the radius *AD* and produce it beyond *D*. Draw the tangent *AF* meeting *BC* in *F*. Make *FG* equal to *FA*. At *G* erect a perpendicular to *BC* meeting *AE* in *E*, which is the centre, and *EG* the radius.

268. TO DESCRIBE A CIRCLE TO TOUCH A GIVEN CIRCLE AND A STRAIGHT LINE *AB* AT A POINT *C*. *First externally:* Find *D*, the centre of the given circle, and draw *DA* perpendicular to *AB*, and produce it to *E*. Join *EC*. Through *F* (where *EC* cuts the given circle) draw *DG* intersecting a perpendicular from *C* in *G*. *G* is the centre and *GC* the radius of required circle. *Second, including the circle:* Find the centre *D*, and draw the perpendiculars *AD* and *CG* as before. Through *E* (the intersection of *AD* with the circumference of the given circle) draw *CF* cutting the circle in F. Through *F* and *D* draw *FG* intersecting *CG* in *G*, which is the centre, and *GC* the radius of required circle.

269. TO DESCRIBE A CIRCLE OF A GIVEN RADIUS *AB*, TO TOUCH TWO GIVEN CIRCLES, AND INCLUDE THEM. Join the centres of the circles and produce the line both ways. Mark off *FE* and *GH* equal to given radius *AB*. With centres *C* and *D* and radii *CH* and *DE* respectively, describe arcs intersecting at *K*, which is the centre of circle required.

270. TO DESCRIBE A CIRCLE TO TOUCH TWO GIVEN CIRCLES *A* AND *B*, AND ONE OF THEM IN A GIVEN POINT *C*. Join *A*, the centre, with *C* and produce. Make *CD* equal to the radius of the other circle *B*. Join *D* and *B* and bisect *BD* by a perpendicular intersecting *CA* produced in *E*, which is

the centre, and *EC* the radius of the required circle.

271. To Describe Three Circles to Touch Each Other, their Radii *A*, *B*, and *C* being Given. Draw any line *DE*, and set off on it *DF* and *FG* equal to *A* and *B* respectively. With *D* as centre and *DF* as radius describe one circle. With *G* as centre and *GF* as radius describe a second circle. Mark off *FH* and *FJ* each equal to *C*. With centre *D* and radius *DJ* describe an arc. With centre *G* and radius *GH* describe another arc intersecting the former in *K*, the centre of the third circle, whose radius is *C*.

272. To Describe a Circle which shall Pass Through Two Given Points *A* and *B*, and Touch a Given Circle *FGC*. Describe any circle passing through *A* and *B*, and cutting the circle *FGC* in *C* and *D*. Through *C* and *D* draw *CE* to meet *AB* produced in *E*. From *E* draw a tangent *EF* to the circle *FGC*. Then *F* is the point where the described circle will touch the given circle. Describe a circle to pass through the points *A*, *B*, and *F*.

Foiled Figures. The following problems relating to foiled figures are exceedingly useful in geometrical design for window tracery and other ornamental forms. It should be observed that in **274-282** the foiled figures are formed of *semicircular* arcs, but in **283** of *tangential* arcs.

273. To Inscribe a Semicircle in an Isosceles Triangle *ABC*. Bisect the angle *BAC* by *AD*. Bisect the angle *ADB* by *DE* cutting *AB* in *E*. Through *E* draw *EF* parallel to *BC*. Upon *EF* describe a semicircle.

274. To inscribe, in an Equilateral Triangle *ABC*, Three Equal Semicircles, Each Touching One Side and Having their Diameters Adjacent. Bisect each angle of the triangle by the lines *AF*, *BD*, and *CE*. Bisect the angle *AFB* by the line *FG* cutting *BD* in *G*. Through *G* draw *GH* and *GJ* parallel to *BC* and *BA* respectively. Join *HJ*. On the lines *HG*, *GJ*, and *JH* describe semicircles.

275. In a Square *ABCD*, to Inscribe Four Equal Semicircles having their Diameters Adjacent, Each to Touch one Side of the Square. Draw the diagonals and diameters. Bisect the angle *EFB* by *FG*, and obtain the inner square *GHJK*. Upon each side of this square construct a semicircle.

276. Within a Regular Polygon, say a Hexagon, to Inscribe as Many Semicircles as the Figure has Sides, Each Touching One Side and having their Diameters Adjacent. Divide the polygon into equal triangles and inscribe a semicircle in each as shown.

277. To Inscribe any Number of Equal Semicircles in a Circle, Each to Touch the Circumference, and have their Diameters Adjacent. Divide the circle into twice as many equal parts as semicircles required. Draw the diameters, and at the end of one of them (say, at *A*) draw a tangent. Bisect the angle *BAC* by *AD*, and obtain *BE*, *BF*, *BG*, and *BH*, each equal to *BD*. Draw the pentagon *DEFGH*, and describe a semicircle on each side.

278. To Inscribe a Semicircle in a Given Square *AKBE*. Draw the diagonals *AB* and *KE*. Describe a semicircle on *AB*. Draw *CD* perpendicular to *AK* and cutting the semicircle in *D*. Join *DE*, and through *F* draw *FG* parallel to *DC*. *G* is the centre and *GF* the required radius.

279. To Inscribe a Semicircle in a Given Trapezium *AEBK*. Draw the diagonals. On the shorter, *AB*, describe a semicircle. From *C* draw *CD* perpendicular to *BK* and cutting the semicircle in *D*. Join *DE*, and proceed as in last problem.

280. In a Given Square *ABCD*, to Inscribe Four Equal Semicircles, Each to Touch Two Sides, and have their Diameters Adjacent. Draw the diagonals and diameters as shown. In each small square, as *BEFG*, inscribe a semicircle.

281. In a Given Equilateral Triangle *ABC*, to Inscribe Three Equal Semicircles having their Diameters Adjacent, and Each Touching Two Sides of the Triangle. Bisect each angle of the triangle by lines which divide the triangle into three equal trapeziums. In one trapezium (say, *ADFE*) inscribe a semicircle as in **279**. Make *FJ* equal to *FH*. Join *HJ* and *GJ*. Upon *HJ* and *GJ* describe the semicircles.

282. In any Regular Polygon (say, a Pentagon *ABCDE*), to Inscribe a Number of Equal Semicircles, each to Touch Two Sides of the Polygon, and have their Diameters Adjacent. Draw the lines bisecting the angles and giving five equal trapeziums. In each trapezium inscribe a semicircle, as in **279**.

283. To Describe a Trefoil of Tangential Arcs, the Radius *AB* being Given. Construct an equilateral triangle *CDE* with sides each double of *AB*. With each angle as centre and *AB* as radius describe the arcs.

284. About a Given Triangle *ABC*, to Describe Another Triangle similar to a given Triangle *DEF*. On *AB* construct a triangle similar to the triangle *DEF*. Through *C* draw a line parallel to *AB*, and produce *GA*, and *GB* to meet it. Then *GHJ* is the triangle required.

285. About a Given Square *ABCD*, to Describe a Triangle similar to a Given Triangle *EFG*. On *AD* construct a triangle similar to *EFG*. Produce the sides to meet *BC*, produced as shown.

286. Within a Given Triangle *ABC*, to Inscribe another Triangle similar to a Given Triangle *DEF*. On *AB* construct a triangle similar to *DEF*. Draw *GC*. From *H* draw *HJ* and *HK* parallel to *GB* and *GA* respectively. Join *JK*. Then *HJK* is the required triangle.

287. To Inscribe an Equilateral Triangle in a Given Square *ABCD*. Draw the diagonal *AC*. On *AC* construct an equilateral triangle *ACE*. From *D* draw *DF* and *DG* parallel to *EA* and *EC* respectively. Join *F* and *G*.

288. To Inscribe a Square in a Given Triangle *ABC*. Draw *AD* perpendicular to *BC*. From *A* draw *AE* parallel to *CB* and equal to *AD*. Draw *EC*. From *F* draw *FG* and *FH* parallel to *BC* and *AD* respectively. From *G* draw *GJ* parallel to *AD*. Then *FGJH* is the required square.

289. To Inscribe a Square in a Trapezium *ABCD*. Draw the diagonals *AC* and *BD*. Draw *AE* parallel to *BD* and equal to *AC*. Draw *BE*. From *F* draw *FG* and *FH* parallel to *BD* and *AC* respectively. From *G* draw *GJ* parallel to *AC* and join *JH*.

290. To Inscribe a Square in a Given Sector *ABC*. Join *B* and *C*. Draw *CD* perpendicular and equal to *BC*. Draw *AD*, and from *E* draw *EG* and *EF* parallel to *CB* and *DC* respectively. Draw *GH* and *FH* parallel to *EF* and *EG*.

291. To Inscribe a Square in a Segment *ABC*. Bisect the chord *AB* of the segment in *J*. Draw *BD* equal and perpendicular to *AB*. Draw *JD* and produce it to cut the arc in *E*. From *E* draw *EF* and *EG* parallel to *BD* and *BA* respectively. Draw *GH* parallel to *EF*. Join *FH*. Then *GHFE* is the required square.

292. Within a Given Circle, to Inscribe a Triangle similar to a Given Triangle *ABC*. At any point *D* in the circumference of the given

circle draw a tangent *EF*. Make the angle *EDG* equal to the angle *CAB*, and the angle *FDH* equal to the angle *ABC*. Join *GH*. Then *DHG* is the required triangle.

293. About a Given Circle, to Describe a Triangle similar to a Given Triangle *ABC*. Produce the base *BC* of the given triangle. Find the centre *L* of the given circle, draw any radius *LG*, and produce it. Construct the angle *FLG* equal to the exterior angle *ACD*, and the angle *HLG* equal to the exterior angle *ABE*. Produce *LH*, *LF*, and draw tangents as shown.

294. To Describe a Square About a Given Isosceles Triangle *ABC*. Bisect the base *BC* of the given triangle by the line *AD*. On *BC* describe a semicircle. Then *AD* will be a diagonal of the required square. Draw *DC* and *DB* of indefinite length, and from *A* draw parallels to meet them

295. In a Given Hexagon *ABCDEF*, to Inscribe an Isosceles Triangle, the Base *HJ* being Given. Draw the diagonal *AD* of the given hexagon. Draw *CE* at right angles to *AD*. Set off *EK* equal to *HJ*. Draw *KL* parallel to *ED*, and *LM* parallel to *CE*. Draw *AL* and *AM*.

296. Within a Given Circle, to Inscribe an Isosceles Triangle, the Base *AB* being Given. Draw two diameters of the given circle *CD* and *EF* at right angles to each other. Make *GH* equal to half the given base *AB*. Draw *HJ* parallel to *CD*, and *JK* parallel to *EF*. Draw *CJ* and *CK*.

297. Within a Given Square *ABCD*, to Inscribe another Square, one Angle to Touch a Side at a Given Point *E*. Draw the diagonals of the given square. With centre *F* and radius *FE* describe a circle. Join the points, *E*, *G*, *H*, *J*.

298. To Inscribe a Rhombus in a Given Parallelogram *ABCD*, having One of its Angles at a Given Point *E*. Draw the diagonals of the parallelogram. From *E* draw *EF* passing through the centre *G* of the parallelogram. Through *G* draw *HJ* at right angles to *EF*. Draw *EJ*, *JF*, *FH*, and *HE*.

299. To Inscribe a Square in a Rhombus *ABCD*. Draw the diagonals, and bisect the angles thus formed. Join *E*, *F*, *G*, and *H*.

300. To Inscribe a Square in a Hexagon. Draw the diagonal *AB*, and bisect it at right angles by the diameter *CD*. Proceed as in **299**.

301. To Inscribe a Regular Hexagon in an Equilateral Triangle *ABC*. Bisect each of the angles of the given triangle by the lines *AE*, *BF*, and *CD*. With centre *G* and radius *GA* describe a circle. Draw *DE*, *EF*, and *FD*. Then *HJKLMN* is the hexagon required.

302. Within a Given Triangle *ABC*, to Inscribe a Rectangle, the Length of One Side, *DE*, being Given. Set off *BF* equal to *DE*. Draw *FG* parallel to *BA*. From *G* draw *GH* parallel to *CB*. Draw *HJ* and *GK* perpendicular to *BC*.

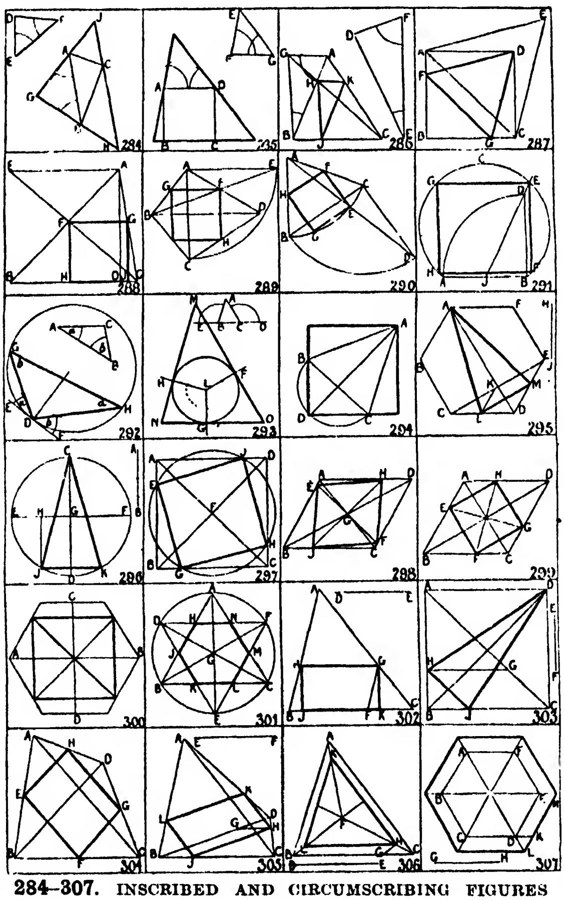
303. In a Given Square *ABCD*, to Inscribe an Isosceles Triangle, the Base *EF* being Given. Draw the diagonals *AC* and *BD* of the given square, and on *CA* set off *CG* equal to the given base *EF*. Draw *GH* parallel to *CB* and *HJ* parallel to *GC*. Draw *DH* and *DJ*.

304. Within any Given Quadrilateral *ABCD*, to Inscribe a Parallelogram, having Given the Position, *E*, of one Angle. Draw the diagonals *AC*, *BD*. Draw *EF* parallel to *AC*, *EH*, and *FG* parallel to *BD*. Join *G* and *H*. Then *EFGH* will be the required parallelogram.

305. Within any Given Quadrilateral *ABCD*, to Inscribe a Parallelogram, having Given *EF*, the Length of one Side. Draw the diagonals *AC*, *BD*. On one of them set off *BG* equal to *EF*. From *G* draw *GH* parallel to *BC*. Draw *HJ* parallel to *DB*, *HK* and *JL* parallel to *CA*. Join *KL*.

306. Within a Given Triangle *ABC* or any Regular Polygon, to Inscribe another similar Figure, having its Sides Parallel to and Equidistant from those of the Given Figure, the Length of one Side, *DE*, being Given. Bisect the angles and obtain the centre *F*. Set off *BG* equal to *DE*. Draw *GH* parallel to *BF*, *HK* parallel to *CA*, *HL* parallel to *GB*, and join *K* and *L*. Then *HLK* is the required triangle.

307. About a Given Triangle or any Regular Polygon (say, a Hexagon *ABCDEF*), to Describe another similar Figure, having its Sides Parallel to and Equidistant from those of the Given Figure, the Length, *GH*, of one Side being Given. Find the centre as before, and produce the lines bisecting the angles. Produce *CD*, and set off *CK* equal to *GH*. Through *K* draw *LM* parallel to *DE*, and the other sides parallel to the respective sides of the given hexagon, as shown.



284–307. INSCRIBED AND CIRCUMSCRIBING FIGURES

How Many Meals Should We Have a Day?
Is Appetite Trustworthy? Cooking of Food.

FOOD AND APPETITE

How many meals should one have a day? That depends on many things. At what hours should one eat one's principal meals? That also depends on many things. In this country, under ordinary conditions, a man usually breakfasts between 8 a.m. and 9 a.m., has luncheon about 1 p.m., and dinner between 7 p.m. and 8 p.m., and the heaviest meal is the last one. Between luncheon and dinner he has usually afternoon tea, with bread-and-butter, cakes, and biscuits. His breakfast usually consists of fish, and ham and eggs, with bread-and-butter; his luncheon is usually a light repast, with little meat; and the main feeding of the day takes place towards night, when he eats a heavy late dinner of three or four or more courses. Four such meals at such hours are physiologically sound. There is time between breakfast and luncheon for the digestion of breakfast; there is time between luncheon and dinner for the digestion of luncheon; and dinner should be fairly well digested before a man goes to bed, about 11 p.m. or so.

Is it Wise to Take a Big Breakfast? The Englishman's breakfast is a much more substantial meal than is taken by most Continental races at that early hour, and it has met with a good deal of criticism. Since his heavy late dinner, he has done, as a rule, comparatively little work, either mental or physical, and he has spent most of the hours resting and sleeping in his bed. Why, then, should he take porridge, and bacon, and eggs, and toast, and butter, and such things? There is an old proverb that "the breakfast makes the man," but the proverb dates from before the time of late dinners.

It may be said, on the other hand, that the nervous system and circulation are rested and particularly fit to cope with the work of digestion, and that the breakfast is really anticipatory. And there is a good deal to be said for this aspect of the matter, provided the luncheon a few hours later is not too heavy. It would, indeed, be a wise rule that breakfast and luncheon should be inversely proportional. Big breakfast, small luncheon; big luncheon, small breakfast. Some people, even in the best of health, do not have much appetite for breakfast. Other people relish their breakfast more than any other meal of the day. There is no advantage of making regular rules for all mankind. Each man has his own digestive idiosyncrasies, and must, to some extent, humour them.

Is a Late Dinner Wise? But, if breakfast be anticipatory, what about dinner when the day's work is over? Is it retrospective? Yes, to a certain extent it is retrospective; for a man in the course of a hard day's work probably uses more energy than he stores, and dinner makes good, and more than makes good, the deficit. *Now*, the work, or the heaviest work, of the day should be over, and the man should be able to sit down with an easy mind to the business of feeding, and should be able to sit quietly after dinner and allow digestion to do its work. To eat a heavy meal in the middle of a strenuous day's work is to invite indigestion, unless it is possible to take about forty minutes' rest before and after the meal. But it must be realised that a man eating four meals a day, or three and a half meals a day, should not require to make any meal a very heavy one. A heavy meal late at night often tells its own tale of physiological transgression by a sleepless night or nightmare.

Afternoon tea is a comparatively modern institution, and many regard it as an altogether pernicious habit. That, again, is a matter for the individual to judge. Personally, if the writer is working he finds that afternoon tea is a most reinvigorating meal: it wakens one up and increases one's working capacity; it also distributes the labour of digestion by enabling one to be satisfied with a lighter dinner. But others do not require the little, interpolated meal, and find that it spoils their dinner, and if that be so they will be far better to avoid it.

Some people find themselves better and fitter if they miss breakfast altogether, but there may be some doubt whether it is quite wise to have no meal from dinner one day to luncheon the next day. Further, to get food of so much fuel value into two meals instead of three means, of course, that more must be eaten at the two meals, and this may have its disadvantages. The same objections apply to the omission of luncheon. But in both cases the man must judge for himself, since physiology has no fixed rule to offer in the matter. Possibly, for a man living a sedentary life and working only with his brains, two meals may be better than three, since they offer less temptation to excess.

Frequent Small Meals not Best. Occasionally it is desirable to have frequent small meals during the course of the day, but only when there is extreme weakness. Frequent small meals are never so good as less frequent larger ones. Digestion is a process that requires time, and to put a meal, however small, into the stomach when it is still working at a previous meal, however small, is to depart from the paths of physiological righteousness.

Punctuality at meals is undoubtedly a good thing. The subconscious mind that rules the organic functions has in some strange way a sense of time, and regularity in meals will be

answered by a preparedness and a regularity in the digestive processes. If we postpone a meal till long past its usual hour the result will be that we have no appetite for the food.

On the other hand, a healthy digestion—that is to say, digestion in a man whose energy is plentiful and on right lines—is very adaptable, and a healthy man can usually miss a meal or postpone a meal without any great inconvenience. When he had to hunt for his food no doubt his meals were not always quite punctual, and probably he not infrequently missed a meal.

Is Appetite to be Obeyed? So far we have said very little about appetite, but appetite is a factor in digestion that cannot be ignored. Is a man with a big appetite to obey his appetite or the ascetic rules of the dietetic authorities? Is a man with a poor appetite to eat as little as he is inclined to eat, or is he to force himself to eat against his desires? Is a man to eat what his appetite craves, or is he to eat what he does not feel the least desire to eat? These are important questions which must be faced and answered.

Unfortunately, they cannot be answered by simple "yes" or "no." There is such a thing as a healthy appetite, and also such a thing as an unhealthy appetite. There is such a thing as a natural appetite, and also such a thing as an acquired appetite. There is a diseased appetite known as *Boulimia*, which gives a man a prodigious appetite; and there are cases known where young girls have an appetite for slate pencils and other doubtful articles of diet.

Within limits, however, the natural appetite, uncoaxed, unvitiated, affords much useful guidance in dietetic matters, and its admonitions should always be regarded with respect. It may require a curb, and it occasionally requires the spur, but it usually knows what is good for it.

Take the case of the appetite of children for sugar and jam. It is an appetite that has been for many years little encouraged. Adults, in their superior wisdom, have considered sugar and jam bad for children. And yet a more scientific knowledge of dietetics has taught us that the child's appetite is right, and that sugar and jam are just the foods the child specially needs to supply ready and concentrated fuel to keep up its incessant muscular activity. Sugar in moderation is good even for adults, and most adults whose appetite and palate are not spoilt by alcohol and tobacco preserve a taste for sweet things. But here we see the necessity of our qualification that the appetite must be unspoiled if it is to be trusted. The appetite of a man who has injured his health by indulgence in alcohol or tobacco will be quite untrustworthy. The appetite of the consumptive will refuse many things good for him and demand many things that are bad for him.

A Mistake to Coax Appetite too Much. Nowadays, too, we coax our appetite with piquant sauces and flavours and pickles to crave more than is good for us, or curb it unnecessarily in a foolish endeavour to get down our weight till it ceases to guide us at all. We tamper with the jury, and we cannot expect a fair verdict.

But the normal, natural appetite is an instinct that deserves respect, and that deserves to be studied and cultivated in the interests of health. Even as it usually leads the child to the jam, so it usually leads the man to what he requires. It is intimately related to taste and smell: taste and smell lose their acuteness when the appetite is satisfied, and much under-eating and over-eating, too, with consequent digestive trouble, are due to the habit of devouring food without masticating and tasting it. The Fletcherites declare that if the food be well masticated the appetite learns to signify when enough has been consumed. "By carefully studying oneself I believe it possible to cultivate an instinct which will regulate not only the quantity but the quality of food that the body may need. . . ."

Appetite the Normal Prelude to Healthy Digestion. Certain it is that appetite is the normal preliminary of ordinary, healthy digestion. It means that the digestive juices are ready to do their work, and that the cells of the body are ready to build tissue and to store energy. We all know how the mouth waters when we smell or see appetising food, and not only the mouth but also the stomach waters.

Pawlow, in his book "The Work of the Digestive Glands," tells how he teased a dog by holding meat beyond its reach. The result was a copious flow of gastric juice. "We are therefore justified," writes Pawlow, "in saying that the appetite is the first and the mightiest exciter of the secretory nerves of the stomach, a factor which embodies in itself a something capable of impelling the empty stomach of the dog in the sham feeding experiment to secrete large quantities of the strongest juice. A good appetite in eating is equivalent from the outset to a vigorous secretion of the strongest juice. Where there is no appetite this juice is also absent. To restore appetite to a man means to secure him a large stock of gastric juice whereby to begin the digestion of a meal."

Lack of appetite means absence of digestive juices, and normal appetite means flow of digestive juices, and therefore, whether the digestive organs be right or wrong in their cravings, they are at least prepared for work, and that is half the battle. If we give food when there is no appetite, we are putting food in the digestive tract when it is unprepared to deal with it, and this must always be a questionable proceeding. To force children, as is often done, and adults, as is sometimes done, to take a meal for which they have no appetite is to put food in the stomach when there is no digestive juice ready to digest it, and the unreadiness of the digestive organs, moreover, is often a sign that the tissues do not need fuel or are not in a position to use it. When a man is fatigued, for instance, his nerve and muscular tissues are poisoned by waste products, and his nerves have not the energy to stimulate digestive secretion—hence he has no appetite. We often foolishly imagine that the fatigue is due to lack of food, and endeavour to force food upon the stomach in order to reinvigorate the fatigued organism, but fatigue is practically never due

to lack of food, and to force food upon the stomach at such a time is to try to force the nervous system and the heart and digestive organs to do unnecessary work when they ought to be resting. Far better than food at such a time would be massage, or hot drinks to assist the circulation and excretory organs to rid the system of the waste products which are poisoning it. There is no need for food at such a time: the food can well wait till the poisons have been cleared out of the organism and till appetite returns. A man should never take a heavy meal after fatiguing work, and appetite in such a case gives him good advice.

So, when a man is worried, or excited, or over-joyous, or over-afraid, he has no appetite: the emotion either depresses or monopolises his nervous system, and the digestive organs, lacking nervous stimuli, fail to secrete digestive juices. Again, in such a case lack of appetite gives information of lack of juice, and the wise man will refrain from forcing food upon an unwilling an effective secretion that ends in undue fat production, and in an undue strain on the excretory organs.

In all cases the best sauce is hunger, and, if hunger be not naturally forthcoming, the hunger produced by cocktails and condiments and culinary sauces is a very poor substitute.

Appetite Comes with Eating. It is often said that appetite comes with eating, and there is certainly a good deal of truth in that. When we eat, the odour and sight of the food, as we have already suggested, stimulate secretion; while, if we chew well, the masticatory action and the sense of taste also act as physiological stimuli. But, further, and this is a very important point, certain foods are capable of stimulating the secretion of the special juices which digest them. This last fact, discovered and investigated by Pawlow, is of great interest.

As we have stated, sense of sight and sense of smell usually initiate digestion, and create appetite before the food is actually in the

PRIMITIVE COOKING: CEYLONESE VEDDAHS PREPARING MEAL

stomach. But in this latter case, and in many other cases, there are quite legitimate and healthy means by which the nerves which preside over digestion may sometimes be recalled to their duty.

The Legitimate Stimulation of Appetite. The nerves which preside over digestion are themselves open to stimulation by other nerves. It is part of the everyday functions of the nerves of taste and smell and sight to set in action the centres which regulate the digestive secretions, and, even as disagreeable tastes and smells and sights put one "off one's food," so piquant tastes and savoury smells and the sight of well-cooked food may produce an appetite that has been in abeyance. So long as these stimuli of appetite are used with discretion, and are not used simply to enable a glutton to over-eat, they can do nothing but good, but too often they are used on wrong occasions, when a man is fatigued or sated, and then, if they do anything at all, they do nothing but harm. Either they do not cause effective secretion, or they produce

mouth; while mastication and the sense of taste served by mastication stimulate still further the flow of digestive juices. Now, Pawlow found that if he put bread directly into the stomach of a dog, so that there was no previous preliminary stimulation of digestive secretion by mastication, taste, sight, and smell, the bread provoked no secretion of juice in the stomach: the stomach remained dry, and the bread lay there undigested. The same occurred if white of egg was introduced directly into the dog's stomach. No juice was secreted: the egg albumen remained undigested. Neither the bread nor the egg albumen can be digested unless there be a secretion of *appetite* juice to set digestion a-going. On the other hand, Pawlow found that milk and meat inserted directly into the dog's stomach in the same way were able by their own chemical properties to excite secretion of gastric juice, and thus effect their own digestion.

This shows us that, in cases of lack of appetite, it is much better to give milk and meat alone than eggs and bread alone. In the former

case there will be some degree of digestion without appetite, while in the latter case digestion will not take place unless appetite has initiated a flow of gastric juice. The indication, evidently, is that in cases of lack of appetite the bread and meat should be taken together in sandwich form, or soaked in meat-juice or milk, or preceded by meat extract or milk.

Physiological Soundness of Ordinary Meals. And now just look at the sagacity of the dietetic instincts of civilised man. We begin dinner very frequently with meat extract in the form of soup. With the soup we eat bread. We then proceed to meat, and, finally, very often to farinaceous pudding. All this is strictly physiological, and, indeed, one could not begin a meal in a wiser way than with meat extract. It is just as wise as cocktails are foolish. Again, we very wisely take milk in our porridge, and put a slice of meat between two slices of bread, and take bacon with our eggs.

Pawlow experimented with various substances to see their value as excitants of gastric secretion, but found that meat extract was much the best. "If," says Pawlow, "one arranged the ordinary fluid food in descending order according to the influence of the chemical excitants the following would be the series: first, the preparations of flesh, such as meat juice and the rest; secondly, milk; thirdly, water."

Of late years, under the example of sanatorium methods, it has become usual to drink milk at luncheon and dinner, and Pawlow's investigations show us that it is a very good thing to do.

Acid fruits and acid drinks are also digestive aids, since they excite a flow of pancreatic juice, and perhaps the sour beverage *kvas* that the Russian peasant takes with his bread and the acid wine drunk by the French peasant are recognitions of this physiological fact.

Quite apart from such direct and indirect chemical stimulation of the appetite as we have mentioned, there are many stimuli of a psychical character. Taste we have already frequently mentioned, and taste acts not merely as a stimulus to the nerve-endings in the mouth and of the nerves of secretion reflexly related to these; it also acts through the emotions, and probably all pleasurable emotions are conducive to good appetite. Many of the amenities of civilised tables are no doubt inspired, though perhaps only half consciously inspired, by a recognition that the digestion is influenced by the emotions. The white tablecloth, the sparkling glasses, the gleaming silver, the flowers, the tastily served dishes, even the dining garments, the feast of reason and the flow of soul, all conspire to favour appetite.

Appetite Improved by Fresh Air and Attention to Food. One little stimulant of appetite, however, is often neglected and omitted. That is fresh, pure, moving air. Respiration and digestion are intimately associated, and there are few appetisers better than fresh air. The air at once makes any banked-up energy current coin, and the digestive functions share the wealth in circulation. It is well known that singers have good appetites, and we all know how much our appetites are improved by a day in the fresh air, and how much they are impaired by hot and stuffy rooms.

In brief, then, we must consider normal appetite a good test of a man's digestive capacity, and a monitor whose advice and warning are to be respected; but we must also realise that it may itself require stimulation and encouragement, and that there are various methods and means, such as meat juice, mastication, fresh air, by which it may legitimately and beneficially be stimulated and encouraged. We must also realise that in the lack of appetite and appetite juice, milk and meat are better than eggs and bread, and that in some cases, especially cases of fatigue, total abstention from food may be best of all.

An Interest in Eating Desirable. There is another fact that is apt to be forgotten with regard to appetite, and that is that the spirit in which food is tackled has much influence over the appetite digestion. The senses of taste and smell and sight all co-operate in the production of appetite and appetite juices; and if one is to make the most of one's digestive capacities and dinner one must *give attention* to what one is eating, and tackle the food with zest, noticing and enjoying its taste and smell. If one carry out George Herbert's counsel, and say dolefully as we swallow our lamb chop, "Dust to dust I commit," we shall get about as much good from our food as if we swallowed a peck of March dust; and if we read a book as we eat, and are more interested in the matrimonial escapades of the heroine than in the taste of our kidney pie, we are certainly not giving our digestive organs fair play. One notices that when children attack their food in an inattentive, lazy way they dawdle over it and lose any appetite they ever had, and cannot finish it, while if they go at it with a certain amount of interest and zest they eat it with ease. One does not find that gourmands and epicures usually suffer from lack of appetite and from indigestion. No doubt at all, lack of appetite is often nothing more than a bad habit, engendered in the first instance by lack of interest in food and by a progressive diminution of diet, ending in an under-nutrition of the digestive organs themselves.

In the case of some diseases there may be lack of appetite juice and yet considerable nutritive competency under the stimulation of suitable food, and in such cases suitable food must be taken, even if the appetite opposes. In consumption, for instance, the toxin in the blood, or some reflex connection between stomach and lungs, often occasions a great distaste for food, and in old days patients were allowed to waste away because it was considered useless to eat without appetite. But, as we have seen, it is not *always* useless to eat without appetite; and if the consumptive be given plenty of milk and meat that provoke digestive juice for themselves he will usually steadily increase in weight.

RONALD MACFIE

Model Cattle Houses, Stables, Barns, and Sheds. The Preservation of Manures. Duties and Payment of Farm Servants.

FARM BUILDINGS AND WORKERS

FARM BUILDINGS

The English homestead is, in the great majority of instances, still of inadequate formation. In the past the custom was to build in the form of a quadrangle or square, the house facing the manure yard, around three sides of which the barn, stables, and cattle buildings were constructed. This method did not conduce to health, however it might have facilitated the farmer's practice of watching both his men and his stock. Whatever the result on this score, the house should be built quite apart from the live-stock and the manure yard, and still further from the dairy—which should not even adjoin the house, inasmuch as danger may follow the presence of sickness—and the water supply, which should be beyond suspicion, and therefore far removed from soil contaminated by manure or sewage.

Selection of the Site. It is important to remember that stock buildings should face the south, the sun having a purifying influence as marked as ventilation. The buildings should be in a fairly high situation, in order to ensure their dry condition and for the purpose of providing natural drainage. Sometimes, too, where the water supply is at the homestead, its conveyance by gravitation to other parts of the farm is facilitated. Again, as the carting of manure involves considerable labour, it is well that it should travel downhill. As far as possible, too, the homestead should be equal in distance from all parts of the farm, otherwise the furthest fields often obtain the smallest quantity of manure and the least attention. It should be near good pasture land, in order that cows, horses, and swine may be turned out with great frequency and therefore with great advantage. Again, it is important that the road or roads to the homestead should be broad and sound, the crown being higher than the sides, and all well metalled and drained.

Cattle Buildings. Buildings intended for cattle should be substantially built of brick or stone, and their roofs slated or tiled, tiles being preferable, as they are cooler in summer and more easily repaired. The floors may be made of fluted concrete to give the animals a firm footing, of grooved firebrick laid in cement, or, in the case of the stalls, of chalk well levelled and covered with beaten earth, which is easily repaired. The house, or byre, intended for cows, which are preferably stalled in pairs, should be carefully planned. For each pair of cows a width of from 7 ft. to 8 ft. should be allowed, depending upon their size, while the depth from the manger, if a manger is supplied, to the edge of the gutter should be from 5½ ft. to 7 ft. Some farmers prefer stalls of the greater length, in which case the manure falls upon the floor, while others prefer short stalls, with the result that the hind feet stand upon the edge of the gutter, and so the manure falls within it, keeping the stalls from being soiled. The gutter should be from 6 in. to 8 in. deep on the stall side, and from 5 in. to 6 in. deep on the passage side. It should be from 12 in. to 15 in. wide, with a fall to the end of the buildings, from which the liquid passes into the drain and tank outside, which should be constructed for its reception and salvage.

In the older type of cow-houses there are wooden mangers with racks above for hay. In a new building it is preferable to abandon the rack and to construct the manger of semicircular glazed fireclay. In this way cleanliness is practically assured, while water can be turned on for the cattle to drink if this be found desirable. In some parts of England, however, no mangers are employed. The hay is placed on the paved floor in front of the cows, while the mixed foods are placed in small, well-painted tubs either direct from a barrow or a tramcar which is wheeled along the passage in front of the animals, or, as in many cases, the tubs are carried to the feeding-house and there filled and returned. Where cows stand in a single row, the passage behind should be 6 ft. in width, for it is here that the removal of the manure and the cleaning of the gutters is conducted. The passage in front of the cows should be at least 4 ft. in width, to enable the feeder to pass along with his food barrow, or, where the animals stand in two rows, head to head, it should be 9 ft., so that two men may simultaneously feed, if necessary.

Feeding Cattle. Where the cattle are fed for the butcher, separate stalls for single or pairs are unnecessary; nor is so much space requisite. The animals are arranged so that as far as possible they cannot harm or rob each other of food, and therefore the smaller and weaker cattle are never placed next to the larger and stronger. Feeding, however, is largely conducted in boxes, a convenient size being 10 ft. by 10 ft., but inasmuch as the manure is not removed practically day by day, and as litter is constantly added, the floor rises, so that a depth of 2 ft. at least should be allowed in addition.

Stables. Stables for farm horses must be roomy, well ventilated, well drained, and well paved. The floors may be of concrete or firebrick, but never paved with stones or soft bricks. A stall 6 ft. in width should be provided for large horses, the floor sloping gradually to the shallow open gutter behind. This gutter, which should also have a fall, should convey the liquid to a drain outside the building, which, in its turn, should carry it to the liquid manure tank. If of concrete, the stall floor should be grooved as in the case of grooved firebricks, in order to give the horses a firm foothold. The stable should be 16 ft. to 18 ft. wide, providing plenty of passage room for large horses and spaces for harness to hang on wall-pegs, as well as for the corn-bins and other necessary equipment. The manger, which is better made of iron than of wood, should be 9 in. deep by 18 in. wide. If wood is employed, it should be the hardest of oak. To admit plenty of light there should be windows, at least 3½ ft. square, made to open with ease, but in any case ventilators of the louvre pattern should be provided, and so arranged that the air is both admitted and returned.

Piggeries. Before constructing a piggery, it is well to examine some of the best of those known to exist, as many quite simple yet practical ideas will be obtained. Where a number of pigs are kept, however, a brick-and-tile building may be provided, with a passage from end to end and sties on either

side, the size varying with the size of the breed. An inner door from the passage should be provided for each sty, together with a trough of fireclay or metal—this adjoining the passage, so that it can be filled by the attendant under cover, the food being brought from the food-house at one end of the building. An opening with sliding door under control from the passage should be provided between the sty and the courtyard outside. Both floors may be of concrete or grooved firebrick, with a slight slope towards a central gutter, which in each case should lead to the liquid manure tank which we have already mentioned.

It is important in constructing a piggery to prevent the possibility of it being undermined by rats. The food-house should be supplied with a copper, or some equally convenient apparatus for cooking food, and with a tank for wash or food which it is intended to soak, where the practice of allowing meal to ferment is adopted. Metal bins are also essential for the preservation of the food.

The Modern Barn. Whether a barn is essential to a farm is a matter which is for the owner to decide. Under the conditions of today, we think no such structure is necessary except for the storage of chaff, which is much improved by packing in large quantities, or the occasional storage of unthreshed corn or of straw. A barn, however, is an expensive building, and may usually be abandoned in favour of an open straw barn, where both hay and corn can be stacked at will and protected against rain during haytime and harvest. Such a building may be constructed of iron—and there are many patterns on the market with arched corrugated roofs—or timber, the roofs in the latter case being of the ridge pattern and the boards fixed with half-inch interstices, through which the rain does not pass if grooves are made near the edges of each. The spaces admit of ventilation without admitting rain, and if the whole structure is well tarred or painted it will last many years, and prove of great value to the farmer.

Storing of Machines. Implement sheds are always necessary. They should be roomy, substantial, and conveniently placed for the storing of drills, rollers, harrows, ploughs, cultivators, horse-hoes, hay-rakes; also mowing-machines and self-binders in particular. It is important that an implement shed should be large enough to permit of such work as cleaning and repairing machinery being carried out beneath it, as, for example, in wet weather, when many other items of labour can be performed under shelter. The roof may be slated or tiled, or even corrugated and painted. A corrugated iron roof of good quality weighs about 5 cwt. to the 100 sq. ft., while slates weigh from 7 cwt. to 9 cwt., and tiles from 8 cwt. to 15 cwt., depending upon the varieties selected. A wooden roof in which the timber is ⅞ in. in thickness weighs about 2½ cwt. per 100 sq. ft. A shed, or portion of a shed, should be reserved for carts, waggons, and the elevator, where this implement is used.

Granaries. A good granary is all-important, and should be constructed of brick on a good foundation, with a smooth concrete floor, if this can be made perfectly dry, otherwise wood may be essential, with ventilation beneath. In this case, it is important to cover all the angles with metal, to prevent the entrance of rats and mice, as large quantities of grain are from time to time left on the granary floor, on which it is dressed or winnowed before delivery. As stock foods, such as cakes and meals, are stored in the same building, the importance of dryness and ventilation will be recognised. There should be glazed windows, covered with fine, strong, perforated metal, facing the south, for the entrance of light and air when necessary. A granary is often one of the great sources of loss on a farm, where, owing to damp and vermin, corn is often damaged or destroyed altogether.

Manures. The salvage of manure, both solid and liquid, being of such importance in the maintenance of the vitality of the land, a tank of a size in accordance with the extent of the farm and the number of stock kept should be constructed in a spot most convenient for the reception of the drainage of the stables, piggeries, and cattle buildings. A tall pump and iron grating should be fitted above this tank, and in the centre of a floor of concrete or grooved firebrick, sloping from the outsides. Through the iron grating the liquid will drain into the tank. The solid manure should be packed above it and around the base of the pump. The manure stack should be built in such a position that the solid excrement from the building can be easily placed upon it from day to day, assuming that it is not directly carried to the land, which, all things considered, is perhaps the most convenient system. Most farmers, however, prefer to heap manure in the yard at some season or other, hence a roof should be erected above the stack to prevent saturation by rain. If packed tidily, the loss will be reduced to a minimum. Liquid manure, however, should never be allowed to remain many days in the tank, unless it is diluted with water, in order to prevent the escape of ammonia. A liquid-manure cart is, however, necessary, so that it can be carried away as often as possible, and certainly as often as necessary. By the adoption of this plan there will be no scattering of manure over the whole yard, and no heaps will be found in front of the doors of the cattle buildings, such as commonly disgrace the farmyard in almost every country.

The Engine. If a portable engine be employed upon the farm, a shed will be necessary for its protection; but if the engine be fixed, the engine-house should be conveniently placed in order that coals may be kept close at hand, and that the various operations of pulping roots, cutting hay and straw into chaff, crushing cake, grinding corn into meal, and driving the cream separator—if such a machine be used—may be economically carried out. This will involve considerable thought in the arrangement of the shafting and the placing of the belts. It is evident, too, that the foods to be handled must be stored for the purpose as conveniently close to the engine-house as possible, while the apartment in which the milk is separated should not be very far distant. It will be for the farmer to decide whether he employs a steam-engine, oil-engine, or petrol-engine, or whether on extensive holdings it will be worth while to lay down a plant which, in addition to the provision of power for the work already named, will also provide electric light.

Reference to the dairy is made in full in the section on DAIRY FARMING. It will now be sufficient to state that, with the exception of piggeries and feeding-boxes, buildings in which stock are kept should be at least 10 ft. in height, that there should be 800 cu. ft. allowed for each cow, 600 for store and fattening beasts, and 1200 for horses, if ventilation is to be perfect and the health of the stock maintained; further, that special care should be observed in selecting dry spots for each building, and in securing as much light as possible coming direct from the sun.

FARM SERVANTS

Duties of the Boy. It is true that the great majority of our farm labourers are the sons of farm labourers, and that they follow their occupation owing to the fact that their earnings are needed by their parents while they are yet children; and, further, that employment upon the farm in which their father is engaged, or by an adjacent employer to whom he is known, is easily obtained. Boys are able to assist the farmer in so many ways, especially during haytime and harvest, when, owing to the holidays, they are permitted to work, that an engagement may not only be obtained, but be retained for life if the servant is willing to satisfy the master. The training of a lad to become a farm labourer is a matter of experience; he gets most of his orders from the men, and tumbles into his work generally rather through a process of imitation than of education.

The boy is generally employed as an assistant to those who are respectively termed waggoners, carters, ploughmen, and horsekeepers or horsemen, in accordance with the custom of the country. The duties of these men are the charge of horses, and the performance of such forms of labour as require the assistance of the horse. These include ploughing and harrowing, cultivating, rolling, drilling, manure carting, mowing and reaping, and in almost all these cases the boy takes his part, assisting in cleaning out the stable, in cutting the chaff, in feeding, in carrying hay and straw, leading the horses when ploughing, where this is essential, riding the fore horse which assists in drawing the binder, leading the horses of the manure cart, driving the horses when harrowing, or raking the hay and the corn.

Promotion. All these and many more duties fall to the farmer's boy, who, with time, becomes more or less accomplished, and is then promoted to the rank of assistant or under carter, or second ploughman. It is true he receives all his orders and many hints from the older men, and he quickly learns not only how to harness and groom, but how to feed a horse properly. It falls to the lot of the farmer's boy, too, to clean the harness when he has learned the way. When he is old enough to take an interest in maintaining good condition in the horses under his charge, he quickly learns to value the quantity of corn and hay they receive, and to take care not only that they obtain the fullest rations which they are allowed, but to embrace every opportunity of obtaining extra food, and especially an occasional mash, a pint of linseed, or a few beans, that he may still further improve their condition.

The farmer's boy is not, however, confined to the stable and the work performed by the horses; he is in great demand among cattle, sheep, and cows. Here he learns to milk, to assist in cleaning out the mangers, the stalls, and the gutters, and in grooming the cattle, a practice which, however, is by no means common. He fetches the cows in from the fields at milking time, morning and night, and takes them back; and, if he is a careful lad, he is entrusted to take the milk twice daily to the railway station.

Pay According to Service. Although the farm boy is generally quick in acquiring a practical knowledge of the work he has to perform, he is not always to be implicitly trusted, and, indeed, he is seldom paid in proportion to his actual value. The difference in the rate of wages paid to a careless lad and one who really does good service to his employer is very slight. The less capable are retained on the farm owing to the dearth of boys, while the capable receive only just sufficient to ensure their retention. If the best workmen—the remark applies to the man as well as the boy—knew their value, they would frequently demand higher wages and assuredly obtain them.

As the useful boy grows into a man he rapidly displays his capacity. He qualifies himself for a first hand by learning to thatch, first assisting an experienced hand during the hay and harvest seasons; he helps in all draining operations, volunteers to trim and lay a hedge, which requires considerable skill, and competes in a ploughing-match, perhaps gaining a prize. His horses are turned out better than those of his neighbours, the harness is cleaner, and the feeding more carefully conducted. If he be in charge of cattle, the cows are well groomed and well milked, the rations are carefully prepared and supplied, and, in consequence, the stock thrive. If fattening stock be under his hand, he does his best to induce them to lay on flesh with rapidity.

Openings for Shepherds. Again, the boy is occasionally handed to the shepherd as an assistant. He learns to recognise the leading ewes of the flock, and he becomes acquainted with their ages, and the importance of identifying their age by their teeth. He is on the look-out for sheep with bad feet, which he quickly understands must be dressed immediately they are detected, and, during the hot weather, for sheep which have been struck by the fly, and others in which the maggot has already appeared, that they may be cleaned and dressed. He thus becomes acquainted with the duties of the shepherding of sheep, and in due course he obtains a place upon another farm as assistant shepherd, and finally as a full-blown shepherd.

From Stable to Stud. It may now be pointed out that highly capable stockmen are always in demand, and they should be far in advance of the average farm stock hand in their knowledge of live-stock, their feeding and management. There are in this country large numbers of breeding studs of Shires and Clydesdales, of Suffolks and Hackneys, of Coach horses and Polos, belonging to men who are often wealthy, and who are willing to pay high wages to first-rate hands. The well-trained farm hand is precisely the individual who is most needed, because it has been his lot to manage horses, and to work long hours at small pay.

Again, there are large numbers of men who breed cattle for show purposes, and who require servants who have been well trained on the farm, and who can be trusted to manage their herds. The wages paid to the stockmen in charge of a breeding or show herd are much superior to those paid on the farm, and, if the remark may be made, there is much more enjoyment in the work, which is varied, which enables a man to see something of the country in which he lives, and which frequently enables him to add a bit of ground to his cottage, and to enjoy the privileges which follow upon its cultivation.

Breeding Sheep and Pigs. Although the opportunities afforded by sheep and pigs are not so numerous nor so profitable, nevertheless there are many instances in which gentlemen who do not make farming a business breed both varieties of stock as a hobby. Pure breeds of sheep are kept either for ram-breeding purposes or for exhibition. In the same way one or more

pure breeds of swine are kept for similar purposes, and placed in charge of men who have acquired considerable knowledge by their experience, so that they are enabled to maintain the stock under their charge in high condition, and to win prizes at the shows to which they are sent. There is in all these cases one qualification essential on the part of the man. He must be a judge of the quality of the breed of stock placed within his charge.

We may take it that, speaking generally, the young labourer marries, rents a cottage, or obtains one from his employer, and settles down to his new life certainly not without hope of advancement. In some cases such a man raises his position by faithful and intelligent service, sometimes being promoted to the position of foreman or bailiff, and occasionally, by the aid of great thrift and industry, emancipating himself from service, and making a livelihood on a few acres of land in or near his native village.

Average Earnings. The system of engagement of farm labourers differs with the locality. In Scotland and parts of Wales, and in the North of England and the North of Ireland, engagements are commonly made by the half-year, single men being boarded and lodged, while married men are provided with cottages. In other parts of the country both married and single men are, as a rule, hired and paid by the week, and left to provide for themselves, although in a large number of instances the married men are supplied with cottages which are let with the farm. The system of boarding and lodging labourers is being gradually abandoned, like the hiring of workpeople at fairs, although these institutions continue to be kept up in the North. In the year 1907 the average rate of wages paid to farm workmen, excluding foremen and casual men, was 17s. 6d. in England, 18s. in Wales, 19s. 7d. in Scotland, and 11s. 3d. in Ireland, or an average of over 1s. per week more than in 1898. Leading men obtained slightly higher wages. The sums paid were highest in Durham in England, and Glamorgan in Wales, while the lowest were in Oxford, Dorset, and Norfolk, ranging from 16s. 4d. upwards.

Wage Supplements. In most English counties the weekly wage is supplemented by piecework, such as hedging and ditching, draining and thatching, sheep shearing and manure spreading, lifting potatoes, mowing, hoeing, and root singling; the total sums earned under these heads range from £5 to £7 per annum. Shepherds, too, usually obtain extra payment for the lambs born or reared, and occasionally stockmen are paid for calves. Another addition to the annual income of the labourer is the harvest pay. In 1904, taking 97 farms from which returns were obtained as a basis, the harvest covered 24 working days, against 33 days in 1902 and 24 days in 1901. The highest earnings were £7 5s. 7d. per man in the Eastern Counties, including Huntingdonshire, Cambridge, and Lincoln. In the Midland Counties these payments averaged £5 13s. 6d., while in the South and South-West the payments on 392 farms averaged £4 17s. 2d. In East Anglia the men usually receive a fixed sum to cover the harvest. In other parts of the country a round sum is paid in addition to the weekly wages, or these wages are increased and beer supplied in stipulated quantities. In some cases, however, the men are paid a fixed sum per day, or a fixed sum plus overtime. It is, however, not an uncommon practice to let portions of the work; and these remarks apply, to a large extent, to haytime and piecework.

Allowances. Farm labourers in many cases receive allowances in addition to their wages. Apart from the cottage, or cottage and garden, with which so many are supplied, they are allowed potatoes, or potato plots, or a given area is planted with potatoes for each man on the farm itself. Again, beer is allowed during harvest, haytime, and threshing, sheep washing and sheep shearing. Beer, however, is replaced by cider in some districts, and by milk, tea, coffee, or cocoa in particular instances. A cow is sometimes allowed grazing, straw is supplied for pigs, or a given quantity of pork or bacon is provided.

In 1907 wages varied in Wales from 16s. 6d. in Cardigan and 16s. 7d. in Montgomeryshire to 19s. 3d. in Glamorganshire. As in some parts of England, wages vary in accordance with the proximity of mines and quarries, the highest sums paid for this class of work largely influencing the wages paid to labourers. It is seldom that wages in cash reach £1 a week: indeed, with allowances added, this figure is not often exceeded. Allowances in kind, however, are not numerous on the Welsh farm.

In Scotland, where the average total earnings vary from 14s. 6d. in Caithness to 21s. 7d. in Dumbarton, allowances in kind are much more numerous. In addition to cottages and gardens, the men receive potatoes or the use of potato-land, fuel, oatmeal, milk, and manure.

Wages in Ireland. In Ireland wages are the lowest in the western counties, reaching from Mayo to Cork. Although hired labourers in this part of the country are very few in number, owing to the fact that the inhabitants occupy the land, which they till for themselves with the assistance of their sons, large numbers of men leave the western counties for England and Scotland, not only during the harvest season, but for months together, their absence frequently extending from haytime to the lifting of the potato and root crops. They live on very small sums, sending the bulk of their earnings home to their families. Piecework is but little practised in Ireland, where the allowances in kind are extremely few. The total weekly earnings of Irish labourers in their own country vary from 9s. 8d. in Roscommon to 14s. in Antrim. Many of the men, however, have the advantage of cheap dwellings with plots of land attached, the average area being about half an acre, although, under the Labourers Acts, it may reach an acre in extent. Through the medium of these Acts nearly 20,000 substantial cottages have been erected, and are let at an average rent, land included, of about 10½d per week.

Hours of Work. The farm labourer's working day is shorter than was formerly the case, the hours depending in a large measure upon supply and demand. In districts where the demand exceeds the supply the men have curtailed the hours. Thus 6 a.m. to 6 p.m., with time for breakfast, lunch, and dinner, has been reduced to 7 a.m. until 5.30 p.m., with time for lunch and dinner only. Horsemen, stockmen, and milkers are usually required to begin at 6 a.m., in some cases still earlier, ploughmen turning out with their teams at 7 a.m. and returning at 2 p.m., in some cases having only stopped work for lunch, and at 4 p.m. in other cases, when they return for dinner and go back to the field. Scotch farmers in England, however, frequently keep their men in the field until 5 p.m.

JAMES LONG

What is Meant by Organic Chemistry. The Power Within Living Things. The Plant as a Synthetic Chemist. Biochemistry. The Carbon Compounds.

ORGANIC CHEMISTRY

The conception of chemistry as divided into inorganic and organic is almost as old as the science itself. It was conceived that there is an absolute distinction between chemical bodies characteristic of living matter and those found elsewhere. It could scarcely be maintained that the living body contained no substances found elsewhere, but those found elsewhere were regarded as, if not accidental, at any rate of scant importance. There remained many substances characteristic of the living body which, it was asserted, could be produced only by living agency. The whole question is so important, having a significance which far outsoars the bounds of chemistry, that we propose to deal with it here very carefully. The question is this: What are the grounds on which we declare that the division of chemistry into inorganic and organic is false and must be abandoned?

The Elements of Life. It is, of course, indisputable that the living bodies of animals and of plants contain chemical compounds, utterly beyond number, which are not met elsewhere. These compounds on analysis prove to be composed of elements already familiar to the chemist, while the number of organic compounds can be estimated only in billions of billions, these not being found naturally, except in the living body. The study of these compounds, in whatever number they are studied, reveals no element peculiar to life. So far as the elements are concerned, there is no foundation for the term *organic* chemistry. Elements constantly found in living organs there may be and are, but no element whatever not found elsewhere.

This is surely what we must expect. We may supply a plant with absolutely nothing but known compounds or elementary substances, such as oxygen, carbonic acid, nitrates, and the like; and we find that in these conditions, if provided with sunlight, it flourishes. The ordinary "inorganic elements" suffice—whether as elements or combined—for its nutriment. If it be killed and its body analysed, it reveals no other element.

Vital Direction. This, of course, is a fundamental fact, and is a conclusion as significant as that of astronomical chemistry when it tells us that the elements of the stars are the same as those of the earth. But there remains the supposition that there is a special and unique power within the living body, whether of the animal or of the plant, which fashions its food so as to form compounds which can be produced by living organisms alone, and which may therefore be called unique. The process is entirely one of building up, or *anabolism* or *synthesis*. Elements or simple compounds are supplied to the plant, and it combines them in such a fashion as to produce starch, sugar, albumen, or what not—which the chemist could not imitate. There is therefore, it would appear, a vital something, a thing incomparable with merely physical forces, and capable of doing what these cannot do.

In virtue of this something, the living organism, though it cannot make new elements, and though it contains no elements peculiar to itself, can yet make new compounds, and is able to display compounds peculiar to itself.

Vitalism. Thus the old distinction of chemistry into organic and inorganic depended upon the doctrine of vitalism, in what we may call its pre-scientific form, which asserted that living things are possessed of a unique force, independent of the law of the conservation and transformation of energy, and capable of accomplishing what even the sum of all the physical energies in the Universe could not accomplish. In this connection one cannot do better than quote from the first volume of Professor Meldola's great work, "The Chemical Synthesis of Vital Products." The professor says: "If asked, as I frequently have been during the progress of the work, what position synthetical chemistry occupies with respect to the doctrines of vitalism and neovitalism, I think it advisable to place upon record the opinion that the present achievements in the domain of chemical synthesis furnish no warrant for the belief that the chemical processes of the living organisms are in any sense transcendental, or that they must be regarded as belonging to a class of special material transformations which human science will never be able to reproduce. Such an admission as the latter would be tantamount to a proclamation of neovitalism; but the whole history of organic synthesis, from the time when it was declared that organic compounds could be obtained only by living agency, is opposed to any such conclusion. But although the doctrine of a special vital force has received its death-blow at the hands of modern science, and although there is no warrant for the belief that the physics or chemistry of animals and plants is ultra-scientific, yet it must not be lost sight of that the synthetical possibilities of the living organism have brought us face to face with modes of chemical action of which we are as yet profoundly ignorant."

The point raised in the latter part of this quotation must, of course, be returned to. Meanwhile, we may content ourselves with this authoritative pronouncement as regards the older vitalism in its relations to organic chemistry. We must carefully remember that neither Driesch nor Bergson had done, when these words were written, the work upon which modern vitalism, a very different thing, is based.

Pioneers. The year 1828 is usually regarded as furnishing the most important date in the history of this subject. It was in that year that Wöhler announced his discovery that it is possible to construct the organic compound urea by synthesis from a salt called ammonium cyanate. As Professor Meldola pointed out more than ten years ago, equal honour must be accorded to an Englishman, Henry Hennell, who "succeeded in synthetising alcohol from olefiant gas at practically the same time as his great German contemporary had excited the interest of the whole chemical world by his synthesis of urea." In neither case was the argument perfect. Hennell obtained his olefiant gas from organic matter—oil, while the German attained his ammonium cyanate "by fusing nitrogenous organic matter with an alkaline carbonate." Only a few years later, however, the arguments were made perfect by the performance of the intermediate steps, and it was absolutely established that certain substances, hitherto thought to be producible only by the living body, could be built up or synthetised by chemists from their very elements. Nor was it necessary to obtain these elements from dead bodies; the nitrogen of the air was as effective for these purposes as nitrogen obtained by processes of decomposition.

The pioneers were bold men, so that, in 1838, the great Liebig and Wöhler dared to say: "From these researches the philosophy of chemistry must draw the conclusion that the synthesis of all organic compounds which are not organised must be looked upon not merely as probable but as certain of ultimate achievement."

The Father of Synthetic Chemistry. There still lived, when these words were first written, the illustrious genius Professor Marcellin Berthelot, who may almost be regarded as the founder of synthetic chemistry. Of modern synthetic chemistry as a practical matter he was certainly the founder. When he began his work, the great names in chemistry propagated sayings such as these. The great Swede Berzelius said: "Even if we should succeed in producing, with inorganic bodies, substances of composition similar to those of organic products, this mere imitation would give us no hope that we could ever produce the actual things themselves, as we succeed, in most cases, in confirming the analysis of the mineral bodies by effecting their synthesis in turn." And Gerhardt put the popular doctrine more effectively when he said: "The chemist does precisely the opposite of living nature: he burns, destroys, operates by analysis, while the vital force alone may synthetise. It rebuilds the edifice which chemical forces have broken down."

But Berthelot soon followed up the pioneer work of Wöhler and Hennell. He made alcohol and formic acid. He began to make fats and sugars; he showed that acetylene, now familiar as a gas for the lamps of motor-cars and so on, can be produced by direct combination of carbon and hydrogen when the electric arc passes between carbon poles in an atmosphere of hydrogen. This gas can be synthetised in half a dozen other ways, its formula being C_2H_2 and its original synthesis by Berthelot led to the making of innumerable compounds, including ordinary alcohol, benzene, and their numberless derivatives. Berthelot's greatest work appeared in 1860, and his name remains as that of the greatest of synthetic chemists.

The most distinguished of his successors is Professor Emil Fischer, of Berlin, who has mastered the making of the sugars, and even, as is far more significant, the making of certain bodies which are at any rate all but proteins.

We may close our account of the history of the subject by reference to the five volumes of Professor Meldola's work from which we have already quoted. The number of vital products that have been made by artificial means ran into tens of thousands long ago, and the prophecy of Liebig and Wöhler is well on the way towards fulfilment.

New Compounds. Not only can an enormous number of vital products be made artificially, but the synthetic chemist has now learnt how to call into being a constantly increasing host of bodies which are closely allied to vital products, but which are entirely unknown in living or in lifeless nature. Of these, thousands and thousands are of interest at present to the chemist alone, but, on the other hand, many fulfil practical functions of the greatest value to mankind. Many most valuable drugs, inducing sleep, relieving fever, relieving pain, destructive to micro-organisms, and so on, have been thus produced—Salvarsan, created since these words first appeared, transcending all its predecessors—while of less importance are the many new dyes synthetically derived from coal-tar. Furthermore, the chemist is able to say that the vital products which he manufactures are strictly identical with those manufactured by the living body, and that such products, whether natural or artificial, are not only composed of the same elements as those found elsewhere, but that what we have previously described as the laws of chemistry are strictly observed. As we have said before, there are not two chemistries, but one chemistry; and any laws applicable to elements in the atmosphere are equally applicable to those elements when they occur in the body of an animal or plant living in that atmosphere. Similarly, all the laws of compounds and of chemical union and disunion, the laws of valency, and so on, are as true in the one case as in the other.

Let us, then, abandon the term organic chemistry, find a new one, and proceed to discuss the substances that come under it. Such would seem to be the natural proceeding, and in the ordinary textbook of chemistry it is followed, but here we have a special aim. We desire not to isolate one science from another, but to co-ordinate them all. And for this reason we must consider a fact which is apt to be forgotten, though it is strictly a fact of chemistry, and though the unravelling of it would mean the making of a new epoch not only in chemistry, but also in the science of life.

Our argument here is practically confined to plants, and for this excellent reason—that the animal body does not enter into competition with the chemist as regards synthesis. With comparatively few, though significant, exceptions, the animal body can effect synthesis only indirectly—when it comes to be inhabited by the mind of man, and when that man becomes a synthetic chemist. The synthesis, which was and is the puzzle, and which plays such an essential part in the economy of living nature, is effected by the plants alone. It is increasingly being shown that the animal body possesses a very small power of synthesis in certain cases, but, though this must be noted, it is of small practical importance. It is the plant that is the consummate chemist. Alcohol and starch and sugar, the albumens, the volatile oils, and a host more, are its products, and the question is this: Having produced a large number of these substances without the intervention of the plant, and being doubtless able to produce any number more; being, further, able to produce a large number of substances which the plant cannot, or at any rate does not, produce, are we not entitled to dismiss the plant from our reckoning altogether?

Man's and Nature's Methods. But this would be the most unpardonable error. Whereas the chemist requires all sorts of powerful reagents, the production of high temperature, long periods of time in some cases, and so on, the plant is totally independent of such conditions. What the chemist produces by the electric arc and the sweat of his brow, or brain, the plant produces in silence, without effort, at low temperatures, and at no obvious cost. We have scarcely begun to attack the true organic chemistry, and we can commit no greater folly than to suppose that our synthetic methods are identical with Nature's, or that, because ours are known, hers are unimportant. Let us hear Professor Meldola, in words which he cannot but recall with satisfaction in the light of the subsequent work of the modern vitalists:

"Those who consider that the triumphs of chemical synthesis have finally disposed of vitalism in any form will do well to bear in mind that until the chemist has shown that his synthetical methods are identical with Nature's methods there is just as much scope for endeavouring to penetrate the chemical vital mysteries as there was in the days when it was believed that every organic compound required an animal or a plant for its production. If this be lost sight of amidst the overwhelming mass of material accumulated by the great army of workers in the field of carbon chemistry, if we have produced thousands of compounds which do not and probably never will be found to exist in living organisms, if we have gone so far beyond Nature as to make it appear unimportant whether an organic compound is producible by vital chemistry or not, we are running the risk of blockading whole regions of undiscovered modes of chemical action by the belief that known laboratory methods are the equivalents of unknown vital methods."

It is essential, as Professor Meldola points out, to turn back and ask ourselves how much light the synthetic chemistry of chemists has thrown upon the synthetic chemistry of plants.

Synthetic and Vital Chemistry. No synthetic processes which produce or involve flame or temperatures anywhere above, say, 103° F. have any particular bearing upon the real question. Says Professor Meldola: "The fundamental synthesis *par excellence*—the photosynthesis [synthesis by means of light], which plants are enabled to accomplish, and in the course of which carbon dioxide is absorbed by an organic compound, and the product or products decomposed with the liberation of oxygen—is as yet without a laboratory parallel." Furthermore, while a very large number—perhaps the whole number—of vital syntheses are accomplished by means of enzymes or ferments, and while the majority of the more familiar products can be also produced in the laboratory, "the analogy between the natural and the laboratory process disappears when it is considered that as yet no organic nitrogenous agent of the nature of an enzyme has ever been synthetised."

It has now been shown by many authors that ferments or enzymes are involved in the building up of a large number of compounds. Even though the stages may be followed by the synthetic chemist, yet the "actual vital method" has not been employed by him. We are bound in honesty to recognise these facts, and not to claim more than we are entitled to. Synthetic chemistry is of the utmost value on the philosophic score. It has clearly demonstrated that substances produced by the living body may be produced without its aid, thereafter exhibiting identical properties in every respect. But it has neither unravelled nor has it in any measure rivalled the synthetic processes as they occur in the living organism.

The Chemistry of Life. There remains a problem of the utmost importance, as the wisest of chemists themselves see. Let us remember that so mighty a chemist as Liebig was content to say that the chemical processes of living matter demanded a vital force for their interpretation. It is all very well for the chemist to deny the existence of vital force, and he is doubtless right. It is all very well for him to compete with the living organism. But is it not plain that if his processes are not the same as its processes, and if its processes are purely chemical or chemico-physical, and not peculiarly vital, there is a great kingdom of chemistry, not even the threshold of which has he yet reached? Of course, this is so; synthetic chemistry has done nothing, or almost nothing, to illustrate the chemistry of living matter. It has merely abolished the old explanation of a vital force, which, of course, was no explanation, but merely a case of darkening counsel by words without knowledge, *obscurum per obscurius*—the obscure by the more obscure. Thus there remains a new science or a newly recognised science, the necessity for which arises the moment we abolish the concep-

tion of a vital force. This science is the chemistry of life, or, as it is commonly called, *biochemistry*. This, of course, is the true organic chemistry; that is to say, if the old term is to be retained at all it should be used not to cover a mere description of the properties of dead starch, on the ground that the starch was produced by a plant, but should be employed to describe the chemistry of living organisms.

The Unknown Kingdom of Chemistry. Our making of definitions has now resulted, it is to be hoped, in a clearing of the ground. Henceforward we shall associate the terms *inorganic* and *organic* chemistry with the definite theory which we may now call the older *vitalism*, and which asserted that so-called vital products are the products of life alone. We shall recognise that these terms ceased to have any valid meaning from the year 1828 onwards. We shall further recognise that, if they are to be retained at all, there is abundant scope for their employment. They are so short and convenient that the present writer would be glad to see them reinstated—inorganic chemistry meaning all such chemical processes as are not peculiar to the chemistry of organisms or organic chemistry. Lastly, we realise that biochemistry, or what we should be pleased to call organic chemistry, is as yet almost an unknown land. It has been claimed for science, and the unscientific conception of a vital force has been dismissed from it, but it has not yet been explored, and the would-be explorer is almost without a guide. But it is, of course, incomparably the richest, the most wonderful, and the most important of all the territories to which chemistry asserts her right. If space avail, we may possibly return to this subject.

The Carbon Compounds. As was mentioned in an early section of this course, we now employ the somewhat clumsy phrase "the chemistry of the carbon compounds" to do the work which was formerly done by the term organic chemistry. The substances with which we shall have to deal are compounds of carbon. Carbon seems to be the keystone of their architecture, and it is from the study of carbon that we are best enabled to attack them. This fact is, in itself, of the utmost significance, for carbon is an abundant and widely-spread ingredient of inorganic nature. It is true that a very large part of the carbon upon the earth once formed part of living bodies. The reader already knows that coal represents the carbonaceous part of the bodies of certain kinds of giant ferns which once flourished upon the surface of the earth. But the doctrine that carbon has always been associated with life, or that it is actually a product of some primeval life, or that it is somehow specially inhabited by the vital principle, must accommodate itself to the fact that *the presence of carbon has been abundantly demonstrated in the stars.* The continuity between the organic and the inorganic is thus demonstrated by the facts of this one element.

Marsh Gas. Furthermore, it would be idle to imagine that all the compounds of carbon belong to the realm of what was called organic chemistry, or, in other words, are specially associated with life. On the contrary, on page 1361, we had to discuss the monoxide of carbon, which has the formula CO, and the dioxide of carbon CO_2. No one thinks of these as coming under the head of organic chemistry. The latter is produced by living bodies, but is also produced—and has identical properties when so produced—by the oxidation of inorganic carbon. There is, therefore, absolute and perfect continuity between the two realms of chemistry, as they used to be conceived. This being granted, we may now proceed to the study of a substance which furnishes the key to the structure of a very large number of other substances of greater complexity, and which, though it might quite well have been treated when we were discussing the other inorganic compounds of carbon, was purposely left over so that it might furnish the basis of the discussion which is to follow. This body is the simplest known compound of the two familiar elements carbon and hydrogen, and is commonly known as *marsh gas*, its technical chemical name being *methane*.

The Hydrocarbons. The term hydrocarbon is used to describe the carbides of hydrogen. Let us once and for all distinguish between two terms which resemble one another—*hydrocarbons* and *carbohydrates*. A carbohydrate is a substance which contains, as its name suggests, carbon, hydrogen, and oxygen, the two latter occurring in the proportions in which they are found in water. The two names resemble one another, but have totally different meanings. The hydrocarbons are far more important, since their existence and structure are fundamental in a study of this part of our subject. The carbohydrates have their own importance, as we shall afterwards see, but it is practical rather than theoretical.

The derivatives of the hydrocarbons are endless and, to quote Sir William Ramsay: "May contain oxygen, nitrogen, sulphur, chlorine, bromine, iodine, and many other elements." Let us now return to certain lessons taught us by the typical hydrocarbon.

Lessons from Marsh Gas. Marsh gas or methane has the formula CH_4, as we saw on page 1764. This is itself of great significance. Says Sir William Ramsay: "The fundamental fact on which the chemistry of the carbon compounds rests is that in them carbon always functions as a tetrad." This means, of course, that the carbon is always "four-handed." We are now past the stage at which it was necessary to accept this fact of valency simply as an inexplicable fact. The new theory of matter, as the reader is already aware, has begun to make it intelligible.

In considering the second lesson of marsh gas we may remind the reader of a previous paragraph, in which it was pointed out that when this body is exposed to the action of chlorine, atoms of the latter gas successively replace atoms of hydrogen, hydrochloric acid being meanwhile formed. We thus get a sequence of bodies,

CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4. Their constitution is thus indicated by graphic formulæ:

$$\begin{array}{ccccc} & H & & H & & & Cl & \\ & | & & | & & & | & \\ H- & C & -H \quad H- & C & -H \text{ etc. to } & Cl- & C & -Cl \\ & | & & | & & & | & \\ & H & & Cl & & & Cl & \end{array}$$

These so-called graphic formulæ are a device of the utmost value. They begin to indicate the *structure of the molecule*, and too much importance cannot be attached to this conception in the pages which are to follow.

"Solid-chemistry." The graphic formulæ represented above have, however, an important defect as symbols. The reader will remember that when we were discussing the new theory of matter we described the now famous behaviour of Mayer's needles, but we had to point out that the needles symbolising the electrons of the atom lie all in one plane upon the surface of the water, and thus represent the atom as a flat or two-dimensional object. But, of course, there is every reason to believe that the atom is a solid or three-dimensional object, and we should like, if possible, to have not a flat but a stereoscopic representation of it, showing the relations of its parts in perspective, as one sees in ordinary vision with two eyes or through a stereoscope.

Now, precisely the same defect attaches to the graphic formula of marsh gas as represented above. It suggests that the molecule is a flat object, lying all in one plane. But it would be a great advance to have some means of representing the molecule in perspective and conceiving of it also as not a two-dimensional, but a three-dimensional object. The introduction of this conception has constituted an epoch in chemistry, and the particular branch of the subject which conceives of molecules and studies them as not flat, but solid objects, is now known as *stereo-chemistry*, the meaning of which we can readily remember by recalling the stereoscope. This great advance we largely owe to the famous Dutch chemist Van't Hoff, until his death professor of chemistry at Berlin.

Substitution. The graphic formulæ above figured illustrate also one of the most important and fruitful ideas in the chemistry of the carbon compounds—and that is the idea of substitution. When, for instance, we compare marsh gas with chloroform we do not simply compare the two empirical formulæ—this being the name applied to the ordinary formulæ—but we compare the two graphic formulæ; and we say that chlorine atoms have been substituted for hydrogen atoms. This theory of substitution we owe to the Frenchman Dumas, friend and rival of Liebig. Liebig at first opposed Dumas' ideas on substitution, but at last he became convinced—says Shenstone in his book on Liebig—"that the character of a chemical substance does not depend so much as he had supposed on the nature of its constituent atoms, and depends very largely also on the manner in which these atoms are arranged. Some years afterwards, at a dinner given by the French chemists to chemical visitors to the Exhibition of 1867, Liebig made his defeat on this occasion the source of a happy retort to Dumas, who had asked him why of late years he had devoted himself exclusively to agricultural chemistry. 'I have withdrawn from organic chemistry,' said Liebig, 'for with the theory of substitution as a foundation, the edifice of chemical science may be built up by workmen; masters are no longer needed.'"

A Small Complexity. It introduces but a small complexity into graphic formulæ to recognise that a certain amount of lack of symmetry may often be met. Indeed, the Dutch chemist whom we have already named has shown that the utmost theoretical importance attaches to the symmetry, or lack of symmetry, of such molecules. Sometimes a single atom having two hands is introduced, and in such a case the molecule becomes somewhat asymmetrical; or, to take the instance of marsh gas again, the four hydrogen atoms may be replaced by two oxygen atoms, giving us a graphic formula like this—$O = C = O$, which of course represents the familiar substance carbon dioxide, and is again symmetrical.

Or we may write the graphic formula of the body CH_2Cl_2 and substitute an atom of oxygen for the two hydrogen atoms that remain. We thus obtain the body carbonyl chloride, the graphic formula of which is:

$$O = C <^{Cl}_{Cl}$$

Carbon Linked with Carbon. Marsh gas does not teach us one of the most remarkable properties of carbon, which goes very far to account for the extraordinary number and complexity of its compounds. This property, other instances of which are very rare, is the power which one carbon atom has of uniting directly with another carbon atom. This we shall come to study when we consider the higher members of the series to which methane belongs, and benzene and its derivatives.

The Properties of Marsh Gas. As we might expect, marsh gas is often produced in marshy ground. It is also very commonly produced in coal mines, thus in both cases having an organic history. It is known to the miner as fire damp, for when mixed with air it forms an easily and extremely explosive mixture. It is a colourless, odourless gas, insoluble in water. The products of its combustion are, of course, carbonic acid and water, and it is hardly necessary to say that it has been liquefied and solidified.

Preparation of Marsh Gas. It is impossible for the chemist to prepare marsh gas by getting carbon and hydrogen to unite directly, except when both elements are in the nascent state. The easiest mode of its preparation is by the action of caustic soda on the acetate of sodium at a considerable temperature. The following is the equation:

$$CH_3CO_2Na + NaOH = CH_4 + Na_2CO_3,$$

sodium carbonate and marsh gas being the products.

C. W. SALEEBY

IN THE DARK DAYS OF RELIGIOUS STRIFE

CALVIN PRESIDING AT THE COUNCIL AT GENEVA IN 1549

 THE BRITISH EMBASSY IN PARIS DURING THE MASSACRE OF ST. BARTHOLOMEW

The Great Struggles for Supremacy in Religion and Absolutism in Government

WARS WAGED FOR RELIGION

In giving our preliminary sketch of the period it is convenient to take familiar points in English history as our landmarks, not because of their intrinsic importance, but because they are handy guides. The first decade, however, of the reign of Henry VIII. provides a starting-point which is of more than insular utility.

A Memorable Decade. In 1509 Henry VIII. became King of England. In 1513 Flodden checked the development of Scotland. In 1515 Francis I. ascended the French throne. In 1516 the young Hapsburg Charles became King of Spain on the death of his grandfather, Ferdinand of Aragon. In 1519 the Emperor Maximilian died, and his death was followed by the election of the King of Spain—who was grandson of Maximilian as well as of Ferdinand—to the imperial throne as Charles V. In 1517 Martin Luther had thrown down the gauntlet to Rome by challenging the sale of indulgences. Thus, at the close of this decade, 1509-1519, the three kings and the religious reformer, whose personalities were to dominate Europe for thirty years—Luther died in 1546, Francis and Henry in 1547, though Charles survived them—had all taken their places on the stage.

A Time of Deep Division. Among them these four laid down the lines of the national divisions of Europe, saw the Europeans masters of South America and on the Indian seas, and marked out the course which was to be taken by the religious Reformation. All four were still living when Ignatius Loyola on the Roman, and John Calvin on the Protestant, side established the types of the Jesuit and the Puritan.

Commercial Strife Follows Religious Strife. Another decade of English history, the decade of the Great Rebellion—or perhaps we should say the two decades of the Rebellion and the Commonwealth—marks a division of our whole period into two. The Peace of Westphalia and the execution of Charles I. were all but contemporaneous, falling precisely midway between the accession of Henry VIII. and the summoning of the States-General. From one point of view, we may regard the first period as that of the ascendancy and decline of the Hapsburgs, and the second as that of the ascendancy and decline of the Bourbons. From another point of view, the first is the period when religious antagonisms are dominant, while in the second those are over-ridden by the claims of rival commercial interests issuing in a great struggle for colonial dominion.

The Rise and Decline of Absolutism. From a third point of view, the first period witnesses the passing of feudalism into absolutism, and the second the decay of the bases on which absolutism was established. In our own island, politically far in advance of other states, the first period saw both the development and the fall of absolutism, while the second established constitutionalism. Thus the chronological division provides a natural partition for our survey. At the opening, then, we find Spain, the Burgundian heritage including the Low Countries, the Central European heritage of the Austrian House, and the Imperial dignity, all under one sceptre, though the Austrian dominions were very soon transferred to the emperor's brother, Ferdinand.

The Balance of Power Theory. The theory of a balance of power among European states would have been stifled at birth but for the fact that the emperor's realms were a heterogeneous assortment of unsympathetic nationalities, very inconveniently situated for united action, whereas the realm of the other great Continental Power, France, was homogeneous and compact. The rivalry of the two princes, Charles and Francis, and their counter claims to sundry Burgundian and Italian territories, were the fundamental facts in the international situation. England, standing outside, her policy guarded—at least in the judgment of the world—by the minister Cardinal Wolsey, sought to hold the balance between the two, to preserve the general peace, and to reap the advantages of her position as arbiter. Failing to keep the peace, she threw her weight—though by no means vigorously—into the scale on the emperor's side; and only after the overthrow of Francis at Pavia in 1525 was an attempt made to restore the balance by a return to the French alliance.

The Bible as Banner. But by this time the new act was making itself actively felt. Martin Luther had challenged the papal pretensions in 1517 at Wittenberg. In 1520 he metaphorically burned his boats when he literally burned the papal Bull which condemned him as a heretic. By challenging the pecuniary and political as well as the theological claims of the papacy, he secured the support of a number of secular princes, while the religious enthusiasm of the masses over half of Germany was aroused by his bold declaration against any authority which pretended to override the Scriptures. "Here stand I. God help me. I cannot do otherwise."

The First Protestantism. The fire was fairly kindled. Politically speaking, German unity had become impossible until the sword which Luther had brought instead of peace should be sheathed. The princes, who supported Luther, demanded religious freedom on the general principle later formulated in the phrase

cujus regio ejus religio—"for each ruler's realm, the ruler's religion." The Lutherans united at Speier in the protest against imperial restrictions which gave to their movement, and ultimately to the whole anti-papal Reformation, the name of Protestantism.

The Menace to Imperial Authority. The new teaching progressed in spite of the serious set-back which it received from the social propaganda of some of its votaries—emphatically condemned by Luther himself—which brought about the horrors of the great German peasant revolt of 1525. The league of Protestant princes became a permanent menace to an imperial authority which definitely ranged itself on the side of the old teaching and was at the same time endeavouring to tighten its control in secular affairs.

Henry the Eighth as State Balancer. Under such conditions an effective Anglo-French alliance would have presented a very grave danger to the Hapsburg monarchy, but the King of England elected to follow a course of his own in which he could be actively associated with neither of the two rivals. While priding himself on his orthodoxy, Henry found conscientious reasons for disclaiming obedience to an ecclesiastical authority which could not be persuaded to declare his marriage with Catharine of Aragon void. Conscience also compelled him to suppress the monastic establishments in England and to appropriate their endowments.

The King-given English Reformation. At the same time the monarch, who had been honoured with the title of "Defender of the Faith" by Leo X., was not *persona grata* with the Lutherans; and the total outcome was that from the hour when Henry began to seek for the so-called divorce from his wife, England ceased materially to influence the policy of either Charles or Francis, while her king was making himself supreme over the State, and the State supreme over the Church. Theological changes, however logically they might follow as corollaries to the revised relations between Church and State, were reserved for the next reign.

The Division of the Hapsburgs. In Germany contests between Protestantism and Imperial Catholicism continued to alternate with periods of doubtful compromises and suspicious truces. The apparent triumph of the orthodox emperor over the Lutheran League of Schmalcald in 1547 was followed by a complete reversal of the position, accomplished in 1552 by Maurice of Saxony; and before the death of Charles a modus vivendi was established between the two parties which remained effective for more than half a century. But the attempt to centralise power in the hands of the emperor had failed, and the intimate connection of the empire with Spain was terminated. A Hapsburg was King of Spain, retaining the Netherlands, and another wore the imperial crown, but the Hapsburg dominion was permanently divided.

While Charles still ruled, Montezuma and Atahualpa had met the fate with which Macaulay's schoolboy was so familiar; Cortez and Pizarro had conquered Mexico and Peru; the Spaniards were established on the Spanish Main, and the Plate fleets were beginning to pour their cargoes into the Spanish treasury. Also, John Calvin had founded his theocratic system at Geneva on a rigid predestinarian basis; the Order of Jesus had been recognised at Rome, and was developing the powers generated by the union of a consummate education with unqualified obedience; and the Council of Trent, in which the adherents of the papacy alone found recognition, was preparing the conclusive dogmatic definitions which were permanently to distinguish Roman Catholics from all others, and to lead to the popular appropriation of the name of Catholic to the Romanists—an abuse of terminology which is excusable only because the opposition of the terms Protestant and Catholic is, on the whole, less misleading than any practicable alternative which has been suggested.

Religious Fluctuations and Balances. In Germany there was a religious truce. In England the explosive Protestantism of Edward VI.'s reign was followed by the still more acute reaction of Mary Tudor's government; and that again by the comprehensive but still limited Anglican settlement of Elizabeth. In France, the orthodoxy of the court was qualified by the Huguenot leanings of powerful families. It remained for Philip of Spain to adopt the rôle of champion of the papacy and hammer of the heretics. Between 1556 and 1560, Spain, France, England, and the Empire each came under a new ruler, who in the case of the first three guided its destinies for some thirty years.

The Scheming of Catharine de Medici. In France the sons of Catharine de Medici were kings, but it was she who controlled them. To retain her own ascendancy she played off the Guises against the Huguenots and the Huguenots against the Guises. Even the terrible St. Bartholomew massacres of 1572, which she planned probably in a moment of jealous panic, failed to suppress the party of the victims, who won the day for their indubitably legitimate candidate, Henry of Navarre, in the struggle for the succession which followed the death of Henry III., and of Catharine herself in 1589, but only when Henry paid the Catholics their price, holding that the possession of a crown was worth a Mass.

Queen Elizabeth's Dependence on Protestantism. In England, the daughter of Anne Boleyn, born out of wedlock in the eyes of every believer in the papal authority, was wholly dependent on the loyalty of her Protestant subjects, whose hopes were no less bound up in her, since, even if her legitimacy were admitted, the legitimate heir presumptive was the Catholic Queen of Scots, who was half a Guise. Elizabeth's domestic administration was consequently emphatically Protestant; the more so when a singularly injudicious papal Bull in 1570 formally invited English Catholics to profess loyalty but to compass treason. Nevertheless, it was her business to avoid challenging

the direct onslaught of the papal champion until the outcome of a struggle could be anticipated with confidence.

Elizabeth's Diplomacy. Hence for nearly thirty years she played persistently a double game, wounding Spain whenever the chance appeared of doing so unofficially, or dangling before France the prospect of a matrimonial alliance, but refusing to commit herself to open support either of the Huguenots in France or of the Protestant Netherlanders in their struggle to free themselves from the Spanish yoke. But sooner or later the battle with Spain was inevitable, apart from the religious question.

The Clash of National Interests at Sea. For the spirit of adventure had taken hold of the seafaring population of England. The Italian Cabots—John and Sebastian—had made their voyages to North America in command of English ships, Willoughby and Chancellor had "discovered" Muscovy when in search of a "North-East Passage," old William Hawkins had made the Guinea voyage and visited the Brazils before Elizabeth was on the throne; and many captains were soon emulating their exploits, most notable among them being John Hawkins, who kidnapped negroes or bought captives from the native chiefs on the Guinea coast, finding a profitable market for the same among the Spaniards in America. But Spain was by no means disposed to let foreigners work their way into sharing her American monopoly, and strict trade regulations were laid down.

Peace at Home and War on the Seas. These regulations the English seamen ignored—partly as being in contravention of treaty rights, partly as having no better warrant than the old Bull of Pope Alexander VI., who had made a present to Portuguese and Spaniards of the New World, which was not his to give. In plain terms, international law was far too vague, and its sanctions far too insubstantial, to control the proceedings of mariners and adventurers on the other side of the ocean. If the Spaniards had a right to the monopoly, the English were no better than pirates; if they had not, the English were within their rights; and the debate could be decided only by the effective, if illogical, method of fighting it out. Therefore, while Elizabeth and Philip were theoretically at peace, their subjects on the high seas and on the Spanish Main were practically at open war.

To War or Not to War? The whole situation favoured Elizabeth's policy of deferring the collision as long as possible. A large proportion of her subjects, and one at least of her ablest Ministers, Francis Walsingham, were eager to join issue with Spain long before the queen or her most trusted counsellor, William Cecil, best known as Lord Burleigh, were willing, partly because they were zealous for England to stand out openly as the champion of Protestantism, partly because the mariners were confident of the outcome of a naval struggle.

THE TRIAL OF CATHARINE OF ARAGON

But Protestantism appealed to Elizabeth merely as a political necessity in her own realms; she cared nothing about maintaining it abroad except as a check upon the capacities of Catholic governments for aggression. She would have preferred friendly relations with Spain on terms of mutual accommodation, wishing to keep that power as a balance to France. The ruin of either France or Spain would, in her view, have rendered the other too powerful. So long as Philip found enough to occupy him in the Low Countries, the prospect of an Anglo-French alliance was a useful diplomatic card in reserve, but a dangerous one to play. In like manner, so long as Mary Stuart lived, it was doubtful whether Philip could reap much advantage from Elizabeth's fall, since Mary's accession might bring about an Anglo-French alliance. But when the marriage of Elizabeth to a French prince had finally become impossible, and the tragedy of Fotheringay had been completed, Elizabeth knew that the fateful grapple with Spain could no longer be averted.

A Clay-footed Colossus. Spain herself was a colossus far less powerful in fact than in appearance. Philip's father had been a Burgundian rather than a German or a Spaniard; Philip himself was a Spaniard without qualification. Lord of Spain, and of the wealth of the Spanish "Indies," he was lord also of the Low Countries, but the sufficient maintenance of communications between Spain and the Low Countries demanded control of the sea. To all appearance, indeed, Spain was incomparably the greatest sea-power, but when she was challenged by England the appearance proved to be fallacious, though this did not occur till Philip's reign was far advanced. Yet, even before that time, it was no easy matter to maintain a large force in the Netherlands; so long as this was necessary, Spain was grievously hampered in other fields of activity, and practically it was necessary almost from Philip's accession.

The Struggle with Dutch Protestantism. The Spanish king was determined to exercise despotic authority and to crush heresy throughout his dominions. The Netherlands, where the nobles and the cities possessed traditional liberties, had no mind to submit to the despotism of an absentee exercised through alien agents and supported by foreign troops. Moreover, the northern provinces which had adopted Calvinistic doctrines were prepared to do battle for their religion at all costs. The organisation of a constitutional opposition to an alien administration and to religious persecution was met by the arrest of two of the leaders, Egmont and Horn, under the government of Alva, whom Philip had sent to replace his own more diplomatic sister, Margaret of Parma. The arrest was answered by a revolt, headed by William, Prince of Orange and his brother, Lewis of Nassau. Egmont and Horn were executed, and the revolt was mercilessly crushed under the iron heel of Alva. There followed a tyranny brutal both in its intentional cruelty and its unintentional financial stupidity.

Annexation of Portugal by Spain. In 1572 the revolt was renewed, and was obstinately maintained, sometimes by the whole of the Netherlands, sometimes by the northern Protestant provinces alone, with assistance more or less surreptitious but tolerably constant from England, and less consistently from France, which of old had claimed suzerainty over Flanders and Brabant. While the struggle was going on, the audacity of the English seamen reached its climax in Drake's voyage of circumnavigation, and his return to England in the "Pelican" or "Golden Hind" with Spanish treasure aboard worth considerably over a million. Incidentally, however, Spain at the same time acquired additional power by the annexation of Portugal on the demise of her king, Henry, on the plea that Philip was the legitimate heir through his mother. For more than half a century Portugal remained an appanage of the Spanish crown, till the House of Braganza succeeded in giving effect to its own claims, of which the legal superiority was indubitable.

War—Open and Understood. The assassination of William "the Silent" in 1584 failed to break down the stubborn resistance of the Protestant Netherlands to Spain. Anglo-Spanish antagonisms became so acute that Elizabeth was unable longer to resist the popular demand for an open support of the Hollanders. England and Spain being openly at war, a live Mary Stuart was no longer a workable political asset. The Queen of Scots was beheaded; Philip resolved to crush Elizabeth and claim the English crown in virtue of his descent from John of Gaunt, and thus simplify the difficult process of crushing the Netherlands.

The Armada Destroyed; the Netherlands Freed. The Armada sailed. In its progress up Channel the superiority of the English fleet was definitely manifested; the Armada itself was finally broken up in the decisive engagement off Gravelines, and its destruction was completed by winds and waves in the course of its flight round Scotland.

The naval war continued for another decade, but the naval supremacy of Spain had vanished for ever. Philip defiantly fitted out one fleet after another, but all met with disaster; and, reduced though his resources were, he threw himself into a French war, instead of strengthening Parma in the Netherlands. When Parma died, there was little doubt that the Hollanders would secure their independence, which they did practically some ten years, and formally some fifty years, afterwards.

Change, Division, and Comparative Peace. In France the war of the succession was terminated by the establishment of the Bourbon dynasty in the person of the quondam Huguenot Henry IV., and toleration was secured by the Edict of Nantes in 1598. In the same year Philip died, to be followed to the grave five years later by his great English antagonist. The succession of the Scots king, James VI., as James I. of England, united England and Scotland under one crown, though the two countries retained separate legislatures and administrations. For nearly half a century to come the intervention of England in European politics was spasmodic and ineffective, almost disregarded by foreign Powers, and of importance chiefly as producing, both directly and indirectly, collisions between the crown and parliament. In Germany the recognition of the principle that each ruler should decide the religion of his own state had brought peace; the German Hapsburgs, unlike the Spanish branch, remained Catholic, but maintained the attitude of compromise.

The Thirty Years' War. On the other hand, the Protestant states became divided into Lutheran and Calvinist, the two camps being in hot opposition to each other. But the time arrived when the heir to the Hapsburg succession and to the empire was recognised in the Archduke Ferdinand, who was a bigoted Catholic. The ruling emperor, Matthias, was king of Protestant Bohemia, where the crown was elective. The Bohemian Diet was surprised into nominating Ferdinand as successor to

DRAKE ENTERING TORBAY WITH A SPANISH GALLEON CAPTURED FROM THE ARMADA

JOHN AND SEBASTIAN CABOT LEAVE BRISTOL ON THEIR VOYAGE OF DISCOVERY

From the painting by Ernest Board, by permission of the artist

Matthias, but an attempt was made to upset the election, reject Ferdinand, and substitute Frederic, the Calvinist Elector Palatine; and thus, in 1618, the Thirty Years' War began.

The Fight for Catholic Ascendancy. In effect, the war was one for the recovery of Catholic ascendancy in Germany. The European championship of the Catholic cause had been taken over from the Spanish by the German Hapsburg. On one side was ranged the German League of Catholic princes, of whom the moving spirit was Maximilian of Bavaria, supported by Spain from the Spanish Netherlands and North Italy. On the other side were the German Calvinists, from whom the Lutherans of Saxony and Brandenburg stood aloof. Victory at first lay with the Catholics; by 1623 it looked as if German Protestantism would be crushed, and the allied Hapsburgs would be able completely to dominate Europe.

Richelieu versus the Hapsburgs. The possibility of such a prospect in 1610 had caused Henry IV. of France to prepare an anti-Hapsburg combination just before he fell under the dagger of an assassin. Now, Richelieu had acquired a preponderant influence in France. For him the enemy was not Protestantism, but the Hapsburgs, though within France the Huguenots were in some degree repressed. Richelieu now intervened, striking at the Hapsburgs in Italy. Although a Huguenot revolt in France compelled him to withdraw again, he had given a lead to the Protestant powers; Denmark and Hungary were drawn into the German struggle on the Protestant side.

The Bohemian Upstart, Wallenstein. At this stage, in 1626, Wallenstein appears to restore the now threatened imperial fortunes, but with a modified policy. He is the champion primarily of imperialism, with the aim of making the emperor master of the empire, playing, *mutatis mutandis*, a rôle analogous to that of Strafford in England or of Richelieu in France. But if the Catholic princes of the empire were willing to be led by their nominal suzerain to the overthrow of Protestantism, they were by no means willing to be ruled autocratically by an emperor whose power rested on an army controlled by a Bohemian upstart. At the moment of Wallenstein's success Ferdinand found himself compelled to choose between him and the league. He chose the league.

Enter "the Lion of the North." But again Richelieu had become active—at least, diplomatically—and the effect of his diplomacy was to bring the Swedish king, Gustavus Adolphus, into the field. The victorious advance of the "Lion of the North" forced Ferdinand to recall Wallenstein to the leadership of his armies. When the two great commanders were pitted against each other, Gustavus lost his life in the hour of victory at Lützen, in 1632. Wallenstein, now incomparably the mightiest figure on the stage, meant to follow out his own policy, in which religious compromise was now a leading feature, while his own aggrandisement was not less prominent in it than his imperialism. But Wallenstein's schemes were ended by the hands of assassins in 1634. In effect, the war now assumed the somewhat unexpected character of a struggle for French supremacy on the Rhine, and for Swedish supremacy on the Baltic. We need not follow its course here. Ferdinand died in 1637, and Richelieu in 1642, but France maintained the same policy under Mazarin, and her armies acquired an unprecedented ascendancy under the leadership of Condé and Turenne.

Effects of the Thirty Years' War. The war was finally brought to an end by the treaties known jointly as the Peace of Westphalia, in 1648. It left Sweden secure in the supremacy of the Baltic, and France in possession of most of the western Rhine provinces. Switzerland and Holland were formally declared independent of the empire and of Spain respectively. As between Spain and France the contest was not terminated till ten years later. In Germany the prolonged devastation of a war, particularly hideous in the brutality by which it was distinguished, left the land seriously impoverished and gravely depopulated. The Protestantism of North Germany had survived the attack, and the wars of religion were ended. But the Catholics had foiled the attempt to establish imperial supremacy at the price of their failure to establish Catholic domination. The Hapsburg was *primus inter pares*, but nothing more. The German states were as far as ever from combining into a single German nation.

England's Futile Favourite. In all these events England had played practically no part. From 1618 to 1628 the administration of James I. and Charles I. was practically in the hands of the incompetent favourite Buckingham, whose policy was guided exclusively by personal piques and ambitions. Everything he did was equally reckless in conception and disastrous in execution. Expeditions to help the Elector Palatine, to strike at Spain, or to help the Huguenots at Rochelle were all fiascoes of the worst kind, but English intervention was ended altogether when the duke was stabbed by an aggrieved and crazy fanatic.

The Rise and Fall of English Absolutism. Under the Tudors, the Crown had obtained complete control of administration, with the general acquiescence of Parliament; while its policy was popular, it had been allowed to wrest the law to its own purposes. The Stuarts endeavoured to exercise, in addition, an effective control of taxation, and to override the law in carrying out a policy which was thoroughly unpopular, with the natural result that Parliament challenged the Crown's administrative prerogatives. The outcome was a civil war which made the victorious army of the Parliament master of the situation. Parliament had played Frankenstein. The army would trust neither the king nor the Parliament; it beheaded the one, ejected the other, and established a Cæsar in the person of Oliver Cromwell. The military protectorate was an abnormal expedient for dealing with abnormal conditions, utterly opposed to all English

THE DEATH OF GUSTAVUS ADOLPHUS ON THE BATTLEFIELD OF LÜTZEN

tradition; triumphant but intolerable. It was doomed to pass away with its mighty creator. Absolutism was to make one more brief effort. But it was, in fact, a lost cause; the ascendancy of Parliament was won. But while the Commonwealth lasted, Europe awoke to the fact that even Van Tromp and De Ruyter were no more than a match for Robert Blake, and that Cromwell's Ironsides under Turenne, as under Cromwell himself, were more than a match for the best soldiery in Europe.

Absolutism in France. Absolutism was rejected by England. During the first half of the seventeenth century it was most decisively established in France. Henry IV. built up a popular despotism, but it was Richelieu who did for France what Strafford tried to do for England and Wallenstein for the empire. In England and France, however, absolutism had different foes. In England it was the traditional rights of gentry and burghers that were at stake; in France it was the claims of a feudal noblesse. In France absolutism was the condition of a strong central government; in England it was to be proved that the ascendancy of Parliament did not weaken the central authority. Richelieu's task was not completed. In the wars of the Fronde, with which his successor Mazarin had to cope, the aristocracy had to be brought to submission, and the Paris *parlement* —not, like the English Parliament, a representative assembly, but a body of lawyers— made an unsuccessful bid for constitutional powers. But the policy of the cardinals prevailed; and when Mazarin died, young Louis XIV. was already the most absolute monarch in Europe.

The English King a French Pensioner. Cromwell, in 1656, had accepted the French proposals for alliance against Spain, in the hope of promoting a Protestant League for the defence of all Protestants. If he had foreseen that, when he was dead, England would lose sight of his purpose in the alliance with France, and that France would be able to use the fruits of that alliance and the defeat of Spain for her own ends, we may presume that his policy would have been different. It is hardly safe to condemn the designs of a statesman because his successors were incapable of giving them effect. The establishment of a pensionary of King Louis on the throne of England did not fall within the Protector's calculations. A. D. INNES

The Permanent Way. Ballast, Sleepers, Chairs, and Rails. Laying, Jointing, and Truing. Wear of Rails. Testing Rails.

THE ROAD OF RAILS

A ROAD of rails, although a great advance upon any other kind of road, differs from it in no essential principle. In the most primitive forms of transport the load is carried by man or animals, and sometimes dragged along the ground. The North American Indians carried their property over the prairie upon poles to which horses were hitched at one end as to shafts, the ends of the poles being allowed to trail upon the ground. When a load is placed upon any form of skid and drawn along, three results ensue: (1) the resistance due to friction and vibration; (2) the destruction of the surface of the ground passed over; and (3) the wear of the skid itself both from friction and jolting. The introduction of so simple a mechanism as the wheel effects a great improvement. The greater part of the friction can be concentrated at the hub thereof, where particular care can be taken to maintain conditions that reduce it to a minimum; also, since the friction is less, the destruction and wear is less, both of the vehicle and of the ground over which it passes.

A Prepared Track. Any considerable load, nevertheless, will force the wheel into the ground, causing resistance to progression and destruction of the surface of the ground unless it is very hard; also the disadvantages of jolting are but little reduced. The next step is to establish a prepared surface of ground to receive the wheel. This involves the disadvantage of confining the movement to the prepared surface, but the out-weighing advantages consist in the great diminution of resistance due to jolting, together with diminished destruction and wear of the vehicle and surface traversed.

The Romans are alleged to have conquered the known world by the introduction of good roads. The road of rails was an advance of almost equal importance. Here the surface over which the wheels pass is so confined and narrow that the hardest metal can be utilised and perfect smoothness insured, thus reducing the resistance due to wear and vibration to the lowest point attained.

Resistance and Traction. A steady pull equal to the weight of 100 lb. will move a ten-ton truck along a level stretch of railway at about ten miles per hour. On a smooth pavement a pull five times as great would be necessary to move a waggon weighing ten tons. On an ordinary macadamised road twice as much or 1,000 lb. would be needed. Over grass, perhaps 3,000 lb. or a ton and a half would suffice, while in the absence of wheels the load would be almost immovable.

If the speed of railway trains were confined to ten miles per hour, a comparatively flimsy construction would be strong enough, but at the high speeds which actually prevail, the action of the locomotive passing over the line is like that of an immense hammer—a steam-hammer, in fact.

Were the rail that carries the train to be supported directly upon a hard rock foundation, that rail, whatever its material, would be hammered out of shape or broken.

Principles of Construction. The rail, therefore, though held in a cast-iron chair to keep it steady, is supported by a wooden sleeper with some "give" in it. The principle of this is easily illustrated. Place a nut upon a hard surface and strike hard enough to crack it. Place it now on a thick piece of indiarubber; the same blow will not suffice to break it. If railway sleepers were placed upon a hard surface, even they would soon be broken up. Sometimes in rough countries they are placed upon the earth, but then the earth soon gives way under the hammering of passing trains, and a further objection is that contact with earth accelerates the rotting and decay of sleepers. The proper plan is to seat the sleepers upon a layer of broken stone called *ballast* or *metal*. It was discovered by the old road-makers Telford and Macadam that stone broken into fragments readily fits itself into a pretty compact mass, and while the stones rock a little under a blow, and thus absorb some of its energy, the pressure is transmitted in rapidly widening circles to the substance beneath them.

Purpose of Ballast. In the same way, upon a railway good ballast receives the shock from the sleepers and protects the earth beneath by distributing the shocks over its whole surface, thus subjecting the comparatively frail earth to pressure of an intensity within its capacity to sustain without flinching. It is this flinching or movement which must at all costs be avoided; if any material of construction, whether it be earth or ballast, will not remain where it is first placed, the integrity of the structure is at an end.

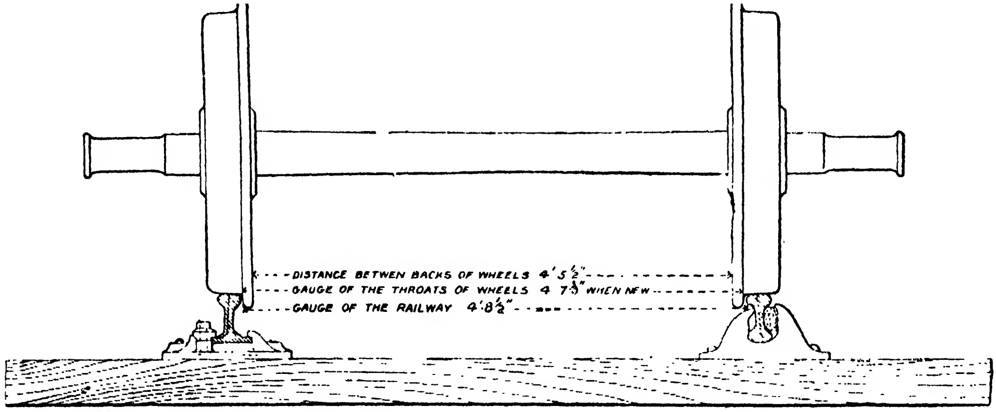
Complete immobility is, of course, unattainable. The aim of the engineer is to make any movement as gradual and uniform as possible; the effect of it will then be rather to strengthen and solidify the road as time goes on, provided that the packing and renewals of ballast are properly kept up.

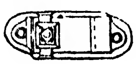
Drainage of the Road-bed. The chief agency in causing undue and uneven movement in the road-bed is, again, water. Every precaution must be taken to keep the ballast and the earth beneath as dry as possible. For this reason a good slope is given to the latter [see 31 and 33, pages 2695 and 2696] so that any water

entering the ballast may quickly drain away. In addition to this, the surface of the ballast over the sleepers is sometimes smoothed over with a fine material, so that the greater part of a heavy rainfall is shed off from the surface at once, and has no time to enter the ballast.

Description of Ballast. The best material for ballast is a hard stone broken into irregular fragments of a size sufficient to pass through a ring two inches in diameter. This, however, is often too expensive to use, and the next best material is clean, coarse gravel. In any case, at least a foot must be interposed between the bottom of the sleepers and the ground or formation level in order effectually to distribute the pressures imposed, and two feet is commonly allowed between formation level and the top of the rails. In stations and yards where men and sometimes horses must walk over the line a great deal, a covering of cinders is placed over the sleepers almost up to the rail level, but in other parts the sleepers are often left uncovered.

When to Lay Ballast. It is usually undesirable to lay ballast down upon an embankment until some time—perhaps a year—after it has been completed. The rails and sleepers may, during this interval, be laid direct upon the earth. Of course, fast traffic cannot be put over the line while it is in this state, but the advantages of the method usually outweigh this drawback. The ballast is most economically laid by bringing it up in trucks by the engine and dropping it between and beside the rails. The sleepers are then lifted and propped up, and the ballast packed beneath them. If this be done too soon, while the earth of the embankment is soft, the soil quickly works up into the ballast, or, rather, the ballast is pounded into the earth, at the same time unduly depressing the centre part of the line, so that a long trough, in which water accumulates, is formed. This water soaks in and softens the middle of the earthwork until the bank may become little better than a raised reservoir of mud, liable to burst at any moment. It is therefore best to allow time for an embankment to become consolidated before laying down ballast, and, in any case, it is necessary to ensure proper drainage.

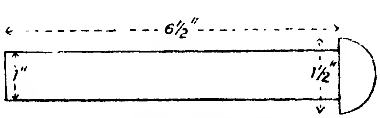


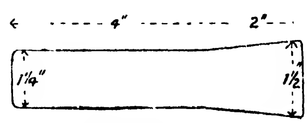


37. SECTION OF TRUCK, SHOWING TWO VARIETIES OF SLEEPERS

Permanent Way. Typical sections of the permanent way of a railway are given in **31** and **33** [pages 2695 and 2696]. In these the ballast is shown carried out to the edge of the slope, which is very flat. The ballast is, however, generally stopped short of this, leaving a margin of about 18 in., called the *berm* or *cess*.

Sleepers in this country are usually of pine, 9 ft. long, 10 in. broad, and 5 in. deep. The edges should be squared, because if they are rounded off there is danger that they have been cut from a tree not sufficiently large to allow of the section being squared, and this is usually objected to, since the wood near the bark of the tree is unduly encroached upon, and the nearer the wood is to the bark of the tree the softer it is, and the more liable to decay.





38. NAILS FOR FIXING CHAIRS TO SLEEPERS

Chairs to carry the rails are almost universal throughout England. They may weigh ½ cwt. each, and should, in that case, present a bearing area to the sleeper of 95 sq. in. and a bearing area to the rail of 10 sq. in. Two varieties of chairs are shown in **37**. The chairs are fastened to the sleepers by nails, two of which are often of wood. A sketch of these is shown in **38**. Usually neither are made with any taper. The keys by which the rails are wedged into the chairs may be made of some hard wood, or

preferably of oak, and are commonly subject to pressure before being supplied for use. For a 56 lb. chair their dimensions would be 7 in. by 3½ in. deep by 2 in. thick, the taper being 1 in 16.

The Position of the Keys. The keys are commonly placed upon the outside of the rail, an arrangement by which a more elastic road is secured, though at the expense of several disadvantages. First of all, there is greater risk of the keys becoming loose, and, although this may be prevented by inserting keys of compressed wood in a very dry condition, this introduces stresses of considerable magnitude tending to rupture the chair, and chairs of defective casting frequently fail from this cause. Secondly, in the event of two or three consecutive keys coming out, the gauge of the line is affected in a more dangerous way than if the keys had been placed inside the rail. Thirdly, when inspecting a line of way a single inspector must walk twice over the ground, up one side and down the other instead of once down the centre, which would be sufficient if the keys had been placed between the rails.

Rails. The rails in such a line as we are considering would have a sectional area of about 8¼ sq. in., and weigh 86 lb. per yd. They are usually rolled in lengths of 30 ft., though the present tendency is to make them longer in order to reduce the number of joints; but when heavy rails are made in great lengths it requires a large gang of men to handle them. In addition to rails of the normal length, it is necessary to provide a number 3 in. or 4 in. shorter for the inner edge of the curves. The object of this is to ensure that the joint on one rail shall come even with the joint of the other rail. The platelayers therefore insert one of these shorter rails whenever a curve is reached, and it is well to remember that approximately 1 in. of difference in the length of the rails of the two sides is required for each degree of curvature.

39. RELAYING GANG PLACING A RAIL LENGTH IN THE CHAIRS

40. GAUGING HORIZONTAL ALIGNMENT OF TRACK

Laying the Rails. The method of laying rails is as follows: First of all the sleepers are brought in trucks or waggons, and laid down approximately according to eye, 11 to every 30 ft., or as many as may be required for the spacing contemplated. It is better to make a mistake by having too many rather than too few, since the sleeper is not always at hand when required. The sleepers having been thus arranged, the chairs are fixed in the proper places upon them, first to those sleepers which are at the extremities of the rails. The keys are then driven into the chairs of these sleepers, fixing them to the rails at the proper distance from their extremities.

The ends of the rails are then brought opposite each other, and the fish-plates are loosely bolted on to ensure the correct longitudinal position of the rail. Small pieces of steel are also placed between the ends of the rails to ensure that they are fixed at the correct distance apart to allow for expansion. The rails being now attached to sleepers at each extremity, the intermediate sleepers are shifted about until they are as nearly as possible in the positions they are ultimately to occupy. Fig. 39 illustrates a gang of men placing a rail length on the chairs.

The chairs are then slipped into position between the sleepers and the rails, and fastened upon the sleeper. This is done by two men; the first precedes with an auger, boring the holes, the second of which follows to drive in the treenails. It will be seen that by this manner of laying the rails the correct position of the chairs upon the intermediate sleeper depends upon the straightness of the rails, and as the rails are not always perfectly straight, it

41. INSPECTOR GAUGING THE TRACK

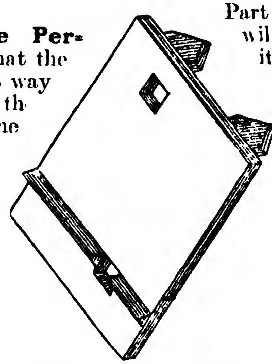
frequently occurs that the chairs are better fastened upon the sleepers before the latter are placed into position. If this be done, it is impossible to get a crooked or bent rail into position at all unless the rail laid parallel to it happen to be bent in exactly the same way. After the permanent way has been laid down in the manner described, the bolts tightened up and the keys driven home, a gang of 10 or 12 men go along the line to remove the slight lateral unevenness unavoidable at the first laying. The men are provided with crowbars [40], and when it is required to shift the lines they stand with their backs to the direction in which the movement is to be made, half the gang on each rail, and, putting the crowbar between their legs, they make a fulcrum of the ground beneath the rail, and so, leaning back together, displace it in the required direction. The ganger or head of the gang walks about 100 yd. behind them in order that he may by looking along the rails be able to tell them readily at what place to stop, as well as the direction and the amount of displacement required. Fig. 41 illustrates an inspector gauging the track.

Essential Features of the Permanent Way. It will be seen that the essential features of the permanent way are the rails, the fastenings of the rails to each other, the sleepers, the fastening of the rails to the sleepers and the ballast. These are, of course, repeated mile after mile over the whole extent of the railway. The result of so much multiplication is to magnify enormously the importance of any modification in the design or relation of the parts, and however slight this may seem it requires the closest attention.

The type of permanent way already described is the one that is commonly used in Great Britain, and it has been found by experience to answer best under the conditions which obtain here. In other parts of the world different arrangements and designs have found favour.

Other Types. In India, where timber of all kinds is subject to the attack of white ants and other pests, cast-iron pot or plate and steel cross sleepers have been used with success. In North America the use of chairs is almost unknown. The rails are of the Vignoles section already described, and are fastened to the sleeper by spikes or nails, as explained when treating of the temporary way, though, of course, the work is much more carefully executed.

Weakness of Vignoles Type. A road so constructed is most likely to fail by the rails spreading, and thus allowing the wheels to run off the rails, especially at curves, where the centrifugal tendency of the rolling stock causes a heavy lateral pressure on the outside rail. This takes place, not because there is any tendency for the rail to slip sideways on the sleeper—frictional force alone is enough to withstand this—but because the rail tends to turn over about the edge of its outer flange and crush the wood beneath it, as well as to draw the dog or spike on the inside. This tendency is commonly met by placing between the rail and the sleeper a bearing plate having holes through which the dogs or spikes are driven. An illustration of this is shown in 42.



42. BEARING PLATE FOR SLEEPERS

General Considerations of Design. The several component parts of the permanent way are dependent one upon the other. To carry locomotives of a given weight at a prescribed speed, no one can be reduced below the standard formed by experience to be sufficient without increasing another. Thus, if the weight of the rails be reduced, the size of the sleepers and their number must be increased. And both the rails and the sleepers need to be of greater weight per mile of road if for any reason the quantity and quality of the ballast be inferior.

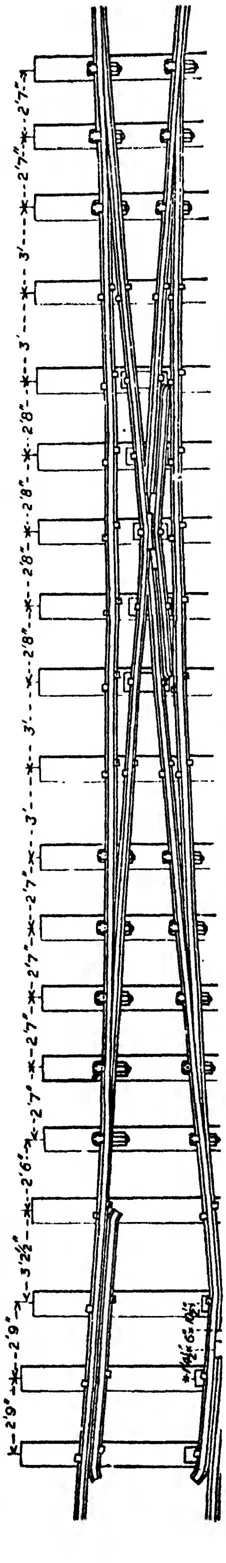
Choice of Ballast. In deciding upon the ballast to be used for a new line, the main consideration is generally the cost of obtaining the various kinds from which choice can be made. Part of the cost of obtaining the ballast will be the expense entailed in bringing it to the spot where it is to be laid down, and this is often an item sufficiently important to cause different types of ballast to be chosen for different parts of the railway. In building a single line of way, the least quantity of ballast that can be employed without involving greater disadvantages than can be compensated for by the saving to be effected by using less amounts to 1,760 cubic yards per mile, which is a cubic yard for each yard of line.

In the absence of hard, durable stone, or satisfactory gravel, slag from the blast furnace in angular pieces is a very suitable material. In places where every kind of hard substance is difficult to obtain, it is often sought to manufacture such a substance by burning a locally obtained clay. In every case in which an artificial material of this kind is adopted it is necessary to make sure that the burnt substance *is* both hard and likely to be durable. And it must be remembered that many rocks to be met with in Nature, though hard enough and tough enough to require the use of explosives to obtain them, will nevertheless prove most unsatisfactory in use. They may soften as the result of exposure to wet; they may scale away and split up under the influence of frost and change of temperature; or they may, in service, produce an undue amount of dust, the effect of which is most detrimental to the rolling stock. Hard limestones and sandstones, and, of course, granite and cognate material, is always to be relied upon. The railway built under conditions in which a plentiful supply of such material is available is a railway built under conditions favourable for economy in maintenance.

Arrangement of Ballast. Many engineers prefer to found the ballasting of a line

on a layer of large stones, and so provide a solid foundation upon which to place the smaller material upon which the sleepers rest. Such stones, when laid together or *packed* by hand, form a structure known as *stone-pitching*. This device is, of course, expensive, and for this reason suitable only for exceptional situations where, from either the presence of an unusual amount of water or extraordinary traffic conditions, special measures are demanded. Experience shows that, unless the packing—*i.e.*, adjusting the ballast beneath the sleepers—of the sleepers is accompanied by ample renewals of ballast these large foundation stones are apt to leave their places, and in subsequent operations of packing to be found near the surface, if not upon it, and interfering with this operation, as on account of their size they can be fitted beneath the sleepers with difficulty. This disadvantage is accentuated if the packed course be laid upon an embankment which is not sufficiently settled and solidified. As well as the ballast beneath the sleeper, it is usual in this country and in many other parts of the world to cover the sleepers with a finer material, reaching to the lower surface of the rails and extending some inches beyond the ends of the sleepers at the sides of the line of way. This is commonly referred to as *boxing-in* ballast; it adds to the weight of the permanent way, and is considered to preserve the sleepers. Doubts have been cast upon its utility, and it has been shown that the boxing-in ballast makes no increase in the resistance of the permanent way to lateral displacement. The merit of this covering-in material as a means of shedding off heavy rain has already been referred to. It may be added that in practice the finer top ballast is very likely from want of care to become mixed up with the layer ballast below it, thus reducing the efficiency of both.

Spacing of Sleepers. The distance apart of the sleepers cannot well be less than 3 ft. from centre to centre, or there will be a difficulty in packing the ballast beneath them to keep a level line. The Americans do space their sleepers more closely but the latter are rather narrower, thus allowing more room for the packing tool to be used between them, and they are also shorter. In the United States, in fact, timber has been relatively cheaper than metal, and it is to such variations in conditions that an engineer must look in order to decide what divergencies from the standard his design of permanent way should show.



43. HALF PLAN OF A SATISFACTORY METHOD OF SPACING SLEEPERS AT A DOUBLE CROSSING

The spacing of sleepers at the places where two lines of railway cross one another, or where a line of railway bifurcates, is always reduced. At such places the course pursued by a train is interrupted. When two lines cross, there is the inevitable jolt at the spot where the flanges of the wheels pass through the gap in the other lines made for that purpose. When bifurcation takes place, an angular lateral deviation of the course of the train is necessarily brought about, creating extra pressures that must be met with extra material. A satisfactory spacing for sleepers at a double crossing is shown in the half plan seen in **43**.

Wear of Sleepers. A sleeper has to be removed from the line ultimately, either because, from the pressure and vibration of passing trains, the fibres of the wood have become separated and broken, or because, from exposure to weather, insects, and other influences, it has decayed. One cause is just as conclusive as the other, consequently there is no object in taking measures for protecting a sleeper from decay for a period longer than it takes to wear it out.

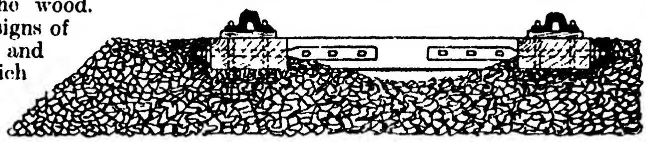
There are several methods of preserving timber, and of these creosoting is the most common. If the wood of which the sleeper is composed includes any *sap wood* of the tree—as the wood near the bark is called—some preservative method is usually essential. If, on the other hand, only hard, or *heart wood*, or wood cut from the centre of the tree, is contained in it, or if the sleeper is to be placed in a situation where the speed and density of the traffic is very great, it is often found that preservative processes are a useless expense, as the sleeper is pounded to pieces by the heavy driving-wheels of the locomotive before the decay begins. The use of chairs between the rails and sleepers enables some economy in the section of the rail, and also increases the life of the sleeper by distributing the pressure upon it over a larger area. The life of sleepers is very variable—anything from 5 to 20 years, according to conditions and circumstances.

Selection of Sleepers. In this country the supply of sleepers is a special branch of the timber

trade. The wood is imported for the most part from parts of Northern Europe, being cut from the forests of fir which abound there. Ability to distinguish between spruce and fir at a glance is very desirable, as the former cannot be recommended for permanent structures out of doors, though on account of its freedom from large knots it is preferred for scaffold poles and such purposes.

Sleepers should be of uniform size, as this assists in securing a uniform support to the rail. They should have a fairly clean surface, since a woolly or ragged surface sometimes left by the saw offers a readier harbour to the organisms of decay. They should, of course, be free from ring shakes, star shakes, and every other form of shake. The spiral grain to be found in many trees commonly converted into sleepers should also be avoided.

Points for Guidance. The twisted fibres frequently cause warping, which interferes with the proper seating of the sleeper upon the ballast beneath. Large knots so frequently found in fir are undesirable. They constitute, in any case, weak places where they occur, and when at or close to the part of the sleeper in which the spikes must be driven they afford reason enough for rejecting the sleeper for any but temporary purposes. The colour of the knots is in fir an indication of the quality of the wood. Bright knots are signs of robust growth and plenty of resin, which discourages organic life. Dull, dark knots have a contrary significance. Sleepers which have not undergone a preservative process, such as vulcanising, creosoting, burnettising, kyanising, etc., should be void of all sap wood, or their durability will be very short. Sleepers which have been so treated may contain sap wood, but it is important to make sure that the whole of the sap wood has been reached by the process which is intended to preserve it.



44. LONGITUDINAL SLEEPER AND RAIL

Varieties of Sleepers. Specifications sometimes require that but one sleeper shall be cut from a single length of tree trunk, thus forming what in the United States of America is called a *pole-tie*. The centre of the tree is then the centre of the tie or sleeper. Such sleepers are considered to be particularly long-lived.

A *slab-tie* is one of two cut from the same length of tree trunk, the centre of the tree coming at the centre of one of the faces of the sleeper, and this face should be placed upon the ballast when the sleeper is in position on the line. The expression *quarter-tie* in the light of the above explains itself. None of these distinctions are of great importance when a process preservative of the timber has been adopted.

In the Colonies, and for light railways in this country, it is not uncommon to use half-round sleepers. This is simply a trunk cut in halves longitudinally, and the bark removed. It is always important to see to the latter even in the roughest construction, since fermentation is apt to be set up within the bark, which quickly leads to the destruction of the wood.

Sleeper Dimensions. Although the standard dimensions for sleepers in the United Kingdom are 9 ft. by 10 in. by 5 in., these sizes are not always followed in other countries, even when the line is of our standard gauge—4 ft. 8½ in. In America from 8 ft. to 8 ft. 6 in. is more usual for the length, 8 in. to 9 in. for width, and 6 in. to 7 in. for depth. American sleepers are therefore shorter, narrower, and deeper than ours. The reduction of length has already been referred to. It is partly explained by the fact that the earthwork on American railways is often skimped, and there is no room for a longer tie. The reduction of width enables the sleepers to be placed closer from centre to centre than would otherwise be the case, and in the absence of a chair avoids too long a bearing surface for the rail. It will easily be understood that the tendency of the rail to bend under the weight of the train passing over it causes it to bear with uneven pressure upon the sleeper. The pressure is greatest first on one edge of the sleeper and then on the other.

Supporting the Rail. The broader the sleeper, or the longer the piece of the rail that bears upon the sleeper, the more accentuated is this effect, with the result that the sleeper rocks on the ballast and works itself loose, while the rail works on the sleeper and cuts across its fibres until the spikes get loose. The introduction of a bearing plate, as explained and illustrated [42], obviates the latter, but not the former tendency. A complete remedy is only to be found in the chair, which not only permits the use of a broad sleeper, but, by distributing the pressure of the rail over the whole surface of the base of the chair, enables the use of a sleeper not so stiff as is found necessary in America, where the sleepers are shorter and more numerous. The explanation of this divergence of practice must be sought in the relative cost of materials. A little reflection will show that by means of the same weight of timber a larger bearing surface of the sleepers upon the ballast would be effected in England in comparison with the usage in America. Thus, timber is economised at the expense of the cast iron used for the chairs.

Treatment of Sleepers. A usual length for sleepers is one and three-quarter times the width of gauge. When building a line of railway through land upon which timber suitable for sleepers is growing and available for the purpose, at economical prices, it is well to provide that they shall be hewed on two sides, that the two sides thus hewed shall be parallel, and that all bark shall be

removed and the ends sawn off square. The trees should be felled as far as possible in mid-winter; midsummer is the next best season. The sleepers should be piled up along the line 7 ft. or 8 ft. from the rails. The piles should rest on two pieces of waste wood or defective sleepers, and should consist of layers of sleepers placed alternately in directions at right angles with each other, allowing plenty of space for the circulation of air between. The sleepers should be so piled six months, if possible, before they are laid down.

Life of Sleepers. In deciding the quality of sleepers to be adopted upon a line, it is necessary to form some opinion regarding the probable life of the various kinds from which choice may be made. If a hard-wood sleeper is expected to last twice as long as another and is quoted at a price half as much again, it becomes a matter of calculation which is really the cheaper of the two; the calculation should not be evaded because the data upon which it must be based is usually somewhat vague in its character. The same applies to processes of preservative treatment. The life of an untreated soft-wood sleeper may be six or eight years, and that of the same sleeper properly preserved 12 or 14 years in similar situations; upon this an estimate of the relative economy of the two may be based, remembering that the longer-lived sleeper has this in its favour, that it remains a longer time before it must be renewed, thus obviating the necessity of so frequently disturbing the track, and in this way favouring smooth running of the trains and less wear and tear on the rolling stock and permanent way.

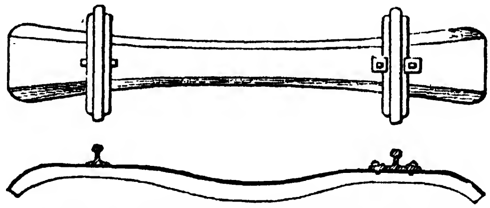
In Great Britain, where timber is dear and money relatively cheap, preservation of sleepers is almost universal. In Canada, where contrary conditions obtain, the reverse is the rule.

Longitudinal Sleepers. The subject of sleepers cannot be dismissed without referring to the system of longitudinal sleepers, which at one time had a great vogue, and is not yet entirely abandoned; particularly as the reason which led to their adoption and the reasons that have since determined their abandonment are good examples of how changes in conditions affect railway design.

An illustration of the longitudinal sleeper and the form of rail associated with it is given in **44**, and also in the reproduction of the photograph [**45**]. Large balks of timber are placed lengthways beneath the rails, giving continuous support. The sleepers are connected every 6 ft. or 8 ft. by transoms of wood, 4 in. by 6 in. These are notched into the sleepers and held by bolts, so that the gauge of the line may be maintained with certainty. Thin pieces of hard wood are laid with the grain crossways between the rail and the sleeper, to prevent the latter being cut into.

45. OLD READING STATION WITH LONGITUDINAL SLEEPERS

Of course these large balks of timber, having to be cut from large trees, are relatively more expensive than the smaller wood that is used for cross sleepers, and drainage is more difficult, as water tends to run along the line of the sleepers. This involves better ballast and more of it. These considerations have been found to outweigh its manifold advantages, and have brought about its disuse, at all events for the time. Less cogent reasons are found in the cumbersomeness of the heavy timber, and the necessity of removing a whole rail when a sleeper had to be replaced in making repairs on the line. Reference to the satisfactory nature of the joint that is made possible by the use of longitudinal sleepers will be made in dealing with the subject of rail joints generally.

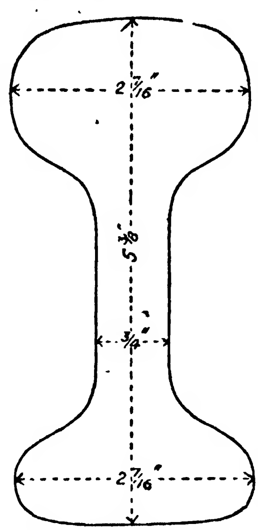


46. STEEL SLEEPER IN PLAN AND SECTION

Iron Sleepers. An immense variety of iron sleepers have been devised. In some, the sleeper and rail have been combined in one longitudinal piece. In others wrought-iron rails have been joined to cast-iron posts. One of the most used forms is the steel sleeper shown in **46**. The illustration explains itself. The arrangement is very useful for temporary work, as it is very light. There are cases also where the material for the permanent way has to be transported so far that the saving in freight of the lighter weight of steel sleepers has caused their adoption. Under ordinary circumstances, however, the relative prices of wood and steel being what they are, the use of steel for sleepers is not economical for the permanent way, unless, as in certain tropical countries, the white ant, or some analogous pest, is to be contended with. In such situations, it is also advantageous to use steel keys in the chairs, if the design of the permanent way adopted requires the use of keys. In fact, keys being in many situations more exposed to the attacks of animal and vegetable organisms than sleepers, it is often found economical to use steel keys with wooden sleepers.

Function of Rails. Rails give the name to the whole construction. All bridges, earthworks, and stations owe their existence to the rails, and the remainder of the permanent way is there for the purpose of supporting them. A railway consists essentially of nothing more than two strips of metal over which the wheels of the rolling stock may run smoothly and easily. Being constructed of steel, rails are able to withstand the blows and abrasion of all the passing traffic concentrated upon the narrow surface they present to it. The excessive pressures to which this surface is subjected, which under fast traffic would quickly destroy any substance weaker than steel, are, by the arrangement and design, so spread out in transmission that they reach the earth below sufficiently diminished in intensity to be without appreciable effect upon it.

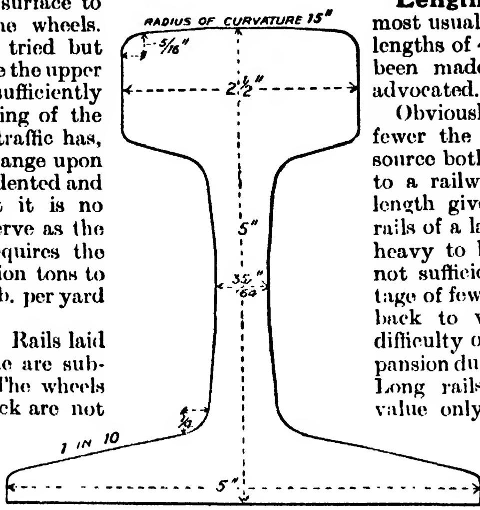
The earliest iron rails were simply strips of iron laid down upon wooden stringers with the object of reducing the amount of wear which obtained with rails made entirely of wood. It still remains a most important part of the function of a modern steel rail to provide metal for the wear occasioned by the traffic, but its function has long been very much extended. A rail must offer a sufficient resistance to bending under a pressure from above to enable that pressure to be extended over several sleepers. Thus the blow delivered upon the rails by a jolt of an engine, which is received at the surface of the rails on the minute area over which the wheels are in contact with the metals, comes to be distributed over an area as broad as the permanent way itself and longer even than it is broad. This is so important that it must be insisted upon even at the risk of repetition. Just as a battleship is armoured against the blows of shot, the earth is armoured against the blows of the engine, otherwise it would be destroyed very quickly.



47. BULL-HEAD RAIL

Sections of Rail. The two most common sections of rail, the *Bull-head rail* and the *Vignoles*, are shown with dimensions in **47** and **48**. It will be easily understood that a very minute divergence in the form of the cross-section being continued throughout the mileage of a railway becomes a matter of great importance. Each square inch in the cross section accounts for 10 lb. per linear yard, so that in weight of material alone a small difference may greatly affect the cost. Consequently, it is important that the cross section of the rail should be designed so that every portion of it may contribute equally to the useful work of the whole. In order to allow for the quick wear, rails that will have to bear a very great deal of traffic, though not heavy fast traffic, will need a greater proportion of metal in the head of the rail than would otherwise be provided. Rails that are to be laid down in thinly populated districts are apt to suffer more from rust than other causes. In such a case, and where the rails may be subject to the action of corrosive gases and other causes of decay, a greater comparative weight of metal in the web—the portion which joins the upper and lower flanges—will conduce to a longer life.

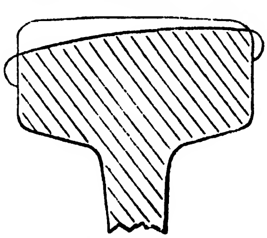
The Vignoles rail, for all round purposes, is usually rolled with 42 per cent. of the metal in the head; 21 per cent. of the metal in the web; and 37 per cent. of the metal in the foot or lower flange. With the bull-head rail practice is not so constant. The similarity of the upper and lower flanges in this case naturally suggests that the rail should be made reversible, so that when the metal provided for that purpose is worn off the head, the rail can be turned over to present another new surface to the abrading action of the wheels. This plan has often been tried but not continued. By the time the upper flange or head has been sufficiently worn to require the turning of the rail, the pounding of the traffic has, by hammering the lower flange upon the seat of the chair, so indented and fatigued the metal that it is no longer in a condition to serve as the head of the rail. It requires the passage of 15 to 25 million tons to wear away $\frac{1}{10}$ in.—*i.e.*, 1 lb. per yard (linear)—off a steel rail.

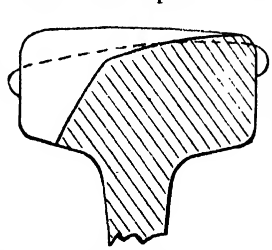


48. VIGNOLES RAIL

Wear on Curves. Rails laid down on curves of the line are subjected to special wear. The wheels of a railway's rolling stock are not arranged like those of road carriages. The wheel of a road vehicle turns round on its axle independently of the other wheel. The wheels of railway carriages and waggons are, on the contrary, fixed fast to the axles, and it is the latter that revolve in bearings provided for the purpose. This allows of a much stronger construction, but a result is that the two wheels fixed at each end of the axle are no longer independent, and must turn together or scrape along the rail.

In going round a curve it will easily be seen that one wheel (that on the outside rail of the curve) has further to go than the other, consequently one or both of them must slip. This slipping action has a very important influence in deciding the alignment of a railway. On a six-degree curve it may double the wear on the rails and affect the wheel flanges to an even greater degree, besides increasing the force required to draw the train. The effect of wear due to this action which obtains on curves is shown in **50**. The effect of wear on straight portions of the line is shown in **49**. Wear is most marked on the outside rail against the inner side of which the flange of the wheel is driven by what is known as centrifugal force. The grinding of the flanges of the wheels wears away the head of the rail at the side as well as at the top of the head. But the inside rail is also ground in a less degree, because as the rectangle formed by the lowest points of the four wheels of a truck is going round a curve it has a tendency to stick, as any other square body that just passed easily between two parallel walls would tend to stick or jamb if the walls made a bend. Altogether the wear on the rails due to curvature amounts to about ½ lb. per degree of curvature, per linear yard per 10,000,000 tons passing over it in gross.


WEAR OF RAIL ON A STRAIGHT TRACK


50. WEAR OF RAIL ON A CURVED TRACK

Length of Rails. Though the most usual length for rails is 30 ft., lengths of 45 ft. and even 60 ft. have been made and used, and warmly advocated.

Obviously, the longer the rail, the fewer the joints; and joints are a source both of weakness and expense to a railway. Of course, increased length gives increased weight, and rails of a large cross-section are very heavy to handle. This, however, is not sufficient to balance the advantage of fewer joints. The chief drawback to very long rails lies in the difficulty of providing means for expansion due to change of temperature. Long rails are therefore of special value only in situations where the range of possible temperatures is moderate.

In laying down the permanent way the platelayers place a small piece of metal, which is often called a *shim*, between the ends of the two rails at each joint to ensure that they shall be laid at a distance apart suitable to allow for the changes of length brought about by variations of temperature. Where 30 ft. rails are being laid, the thickness allowed may be $\frac{5}{16}$ in. for the coldest weather and $\frac{1}{16}$ in. for the very hottest. About $\frac{3}{64}$ in. is required for every 20° F. in the range of temperature.

When laid upon a curve the length of one rail must be increased or reduced a little, or, since the inner rail is the shorter of the two, the joints on this rail will gain upon the joints on the outer rail. If θ be the angular divergence of the curve and r ft. the radius of the outer rail, the difference in length will obviously amount to $\theta r - \theta(r - 4{\cdot}83)$ for a line of standard gauge. Thus the difference for each degree becomes $\frac{4{\cdot}83 \times \pi}{90 \times 2} = {\cdot}084$ ft. or 1 in. nearly. Hence, it is common to provide a number of rails cut 4 in. shorter than the rest, *i.e.*—29 ft. 8 in., and to allow three for every 12 degrees of curvature.

R.W. WESTERN

The Prose Fiction of the Victorian Era. Bulwer-Lytton, Disraeli, Thackeray, Dickens, the Brontës, and George Eliot.

FROM SCOTT TO STEVENSON

If we ever had any measure of doubt as to the importance of the novel in the literature of our country, we could have gone but a little way in the study of nineteenth century fiction ere we realised that one of the chief glories—if not, indeed, the chief glory—of English letters during that period was the novel. We have seen how the novel originated, how it was acclimatised in England, and how in the prose fiction of Scott it reached, so soon in its history, the very height of its possibilities. In the present study we shall follow its development from the time of Scott to the close of the last century, but confining our attention only to the novelists whose careers have been rounded off by death. The most striking fact disclosed by this survey is the evolution of what was originally a form of amusement into an instrument of social, political, and religious propaganda. One often hears about "the novel with a purpose," as though it were a new thing, but long ago Dickens and Charles Reade proved that the novel was a powerful means—perhaps the most powerful—of awakening the conscience of the nation. Although the novel with a purpose has flourished, and still flourishes with us, there are signs, towards the close of the period dealt with, of a return to romance.

One of Scott's contemporaries and followers in fiction was John Galt (b. 1779; d. 1839). Galt wrote a long series of Scottish tales, and was the real progenitor of the so-called "Kailyard School" of Scots fiction, which came so much to the front in the last decade of the century. The pathetic "Autobiography of Mansie Waugh," often attributed to him, was, however, the work of David Macbeth Moir (b. 1798; d. 1851). James Justinian Morier (b. 1780; d. 1849) also wrote several Oriental romances. In "The Adventures of Hajji Baba in Ispahan" his intimate knowledge of Persian life is displayed to manifest advantage.

The art of romance writing is also well exemplified in "Salathiel," "Tales of the Great St. Bernard," and "Marston," of the Rev. George Croly (b. 1780; d. 1860). John Wilson (b. 1785; d. 1854), the "Christopher North" of "Blackwood's Magazine," was, like Galt, a follower of Scott. His "Lights and Shadows of Scottish Life" and "The Trials of Margaret Lindsay," on which his reputation as a fiction writer may be said to rest, are, however, but little read today. Thomas Love Peacock (b. 1785; d. 1866) poured no little wit and knowledge of character into the seven novels which stand to his name—"Headlong Hall," "Melincourt," "Nightmare Abbey," "Maid Marian," "The Misfortunes of Elphin," "Crotchet Castle," and "Gryll Grange." In these works whimsical humour is set off by the songs and lyrics scattered through them.

Frances Trollope (b. 1780; d. 1863), the mother of Anthony Trollope, was an industrious writer, and her books appeal to students of the manners and the temper of one of the most interesting periods of modern English history. Susan Edmonstone Ferrier (b. 1782; d. 1854) was a caustic but kindly hearted delineator of old maids, pretty inanities, gauche doctors, and mock heroes. Like Maria Edgeworth and Fanny Burney, Miss Ferrier, in "Marriage," "The Inheritance," and "Destiny," laid bare the "humours" of her time. A gifted satirist of her sex, she found a wealth of material in the society amidst which she moved in Edinburgh.

The character not less than the literary gifts of Lady Morgan (b. 1785; d. 1859) are well illustrated in her novel, "The Wild Irish Girl." Mary Russell Mitford (b. 1787; d. 1855) wrote "Our Village," a series of delightful sketches which enshrine the life of the little hamlet of Three Mile Cross, near Reading, with a fidelity borrowed from Crabbe, a smoothness that recalls Miss Austen's pictures of Steventon, and a pleasant humour that was all her own.

The Romance of the Sea. The modern novel of the sea saw its development in the hands of MICHAEL SCOTT (b. 1789; d. 1835), author of "Tom Cringle's Log" and "The Cruise of the Midge," two of the best sea stories ever written, though discursive and lacking literary grace; JAMES HANNAY (b. 1827; d. 1873); EDWARD HOWARD (d. 1841), who wrote "Rattlin the Reefer"; and culminated in the extravagant but popular romances of CAPTAIN FREDERICK MARRYAT (b. 1792; d. 1848) and WILLIAM HENRY GILES KINGSTON (b. 1814; d. 1880). Marryat's "Peter Simple," "Jacob Faithful," and "Mr. Midshipman Easy" are perhaps the best and most popular of his many works. Their author owed much to his study of Smollett, whose influence is also revealed in the novels of THEODORE EDWARD HOOK (b. 1788; d. 1841), the author of "Jack Brag." Hook's gift for satirical caricature was probably not without influence on Dickens.

RICHARD HARRIS BARHAM (b. 1788; d. 1845), author of the ever entertaining "Ingoldsby Legends," and friend and biographer of Hook, wrote one novel in his later years, "My Cousin Nicholas." MARGUERITE, "the most gorgeous" COUNTESS OF BLESSINGTON (b. 1789; d. 1849) was the butterfly of a day. Her numerous novels, together with the "Keepsakes" and "Books of Beauty" which she edited, are now forgotten. The veil of oblivion has also fallen over the historical novels of ANNA ELIZA BRAY (b. 1790; d. 1883). EDWARD JOHN TRELAWNEY (b. 1792; d. 1881), the friend of Shelley and Byron, will long be remembered through his delightful "Adventures of a Younger Son."

The Romance of War. With WILLIAM HAMILTON MAXWELL (b. 1792; d. 1850) we come into touch with a school of military novelists which also included GEORGE ROBERT GLEIG (b. 1796; d. 1888), CHARLES JAMES LEVER (b. 1806; d. 1872), author of "Charles O'Malley" and some three dozen other rollicking Irish stories, many of them extremely entertaining and extremely untrue to life, and JAMES GRANT (b. 1822; d. 1877), of whose fifty-odd works "The Romance of War" and "Adventures of an Aide-de-Camp" are still worth reading. The "Traits and Stories of the Irish Peasantry" well represent WILLIAM CARLETON (b. 1794; d. 1869); and of the writings of SAMUEL LOVER (b. 1797; d. 1868), another Irish novelist, "He Would be a Gentleman" and "Handy Andy" are among the best. JOHN BANIM (b. 1800; d. 1842) and MICHAEL BANIM (b. 1796; d. 1874) collaborated in "The O'Hara Tales," a series of melodramatic stories illustrating Irish life, which is also reflected in the novels of MRS. S. CARTER HALL (b. 1800; d. 1881). MARY WOLLSTONECRAFT SHELLEY (b. 1797; d. 1851) wrote in "Frankenstein" a novel which, despite its horrible theme—the creation by a student of a semi-human monster—possesses sufficient of the elements of human interest to preserve it from oblivion.

A Word on Melodrama. The historical novels of GEORGE PAYNE RAINSFORD JAMES (b. 1799; d. 1860) possess little interest today save that they illustrate how a man with sound knowledge, but little imagination, may imitate the example of such a genius as Scott without conveying a scintilla of the vivacity or charm of the model. Much the same may be said of the romances of WILLIAM HARRISON AINSWORTH (b. 1805; d. 1882), except that Ainsworth may be considered as the father of the novel which depends upon a succession of exciting incidents for its popularity—that is to say, the melodramatic novel. Much of the fiction which is most popular today is sheer melodrama, and possesses no likeness to life. Merely to invent "situations" and bend the whole tale to fit these incidents is to produce a low, but popular, because readable, form of fiction.

George Borrow and Others. Passing the one novel ("Deerbrook") of HARRIET MARTINEAU (b. 1802; d. 1876), and the essays in fiction of DOUGLAS WILLIAM JERROLD (b. 1803; d. 1857), we find much that is worthy of careful study in the works of GEORGE HENRY BORROW (b. 1803; d. 1881), whose "Lavengro" and "The Romany Rye" did so much to inspire "the renascence of wonder." They are made classical by the virile simplicity of their style.

The Novels of Bulwer-Lytton. EDWARD GEORGE EARLE LYTTON BULWER-LYTTON (b. 1805; d. 1873) was, in a sense, a parent of the penny novelette. With a versatility akin to genius, he turned his hand to many kinds of literary work, and succeeded, for a time at least, in nearly all that he attempted. There were two exceptions—he failed as a poet and he made a sad hash of his private life by an ill-advised marriage. One of the most prominent and, during his lifetime, one of the most popular of the Victorian novelists, he played a part in fiction similar to that played by Byron in poetry. He posed as the man of the world in "Pelham," as the man of feeling in "Ernest Maltravers" (which Miss Barrett admired against Browning's severer judgment), and as the man of mystery in "Zanoni." The novel of horrors has in "A Strange Story" a supreme example; than "The Haunted and the Haunters," contributed to a magazine which had hailed Lytton as a charlatan, no better ghost story has been written. Lytton essayed the historical romance in "The Last Days of Pompeii," "The Last of the Barons," "Rienzi," and "Harold"; the criminal novel in "Paul Clifford" and "Eugene Aram"; and the novel of domestic life and ambition in "The Caxtons," "My Novel," and "What Will He Do With It?"

It is easy to condemn Lytton, as it was easy, once the trick of his style had been caught, to imitate or to satirise his work, but this work has a certain importance for the student of literature of the period in which Lytton wrote, and of the evolution of the English novel. For a time Lytton's success eclipsed the popularity of Scott; that Scott came to his own again, and that Lytton now occupies a comparatively minor place in English letters, are facts the reasons for which will soon be fairly obvious to any conscientious student. ROBERT SMITH SURTEES (b. 1803; d. 1864)—

"Jorrocks"—wrote a number of sporting sketches which are believed to have suggested to Dickens the plan of the "Pickwick Papers."

Lord Beaconsfield as a Novelist. A writer who, with Ainsworth and Lytton, came under the lash of Thackeray's pungent satire, but who was a much greater man than either, was BENJAMIN DISRAELI (b. 1804; d. 1881). Disraeli's career and versatility afford a parallel to the life and activities of Lytton; but the author of "Vivien Grey," "The Young Duke," "Contarini Fleming," "Henrietta Temple," "Venetia," "Coningsby," "Sybil," "Tancred; or, the New Crusade," "Lothair," and "Endymion" won greater distinction as a statesman than as a novelist, and his works are valuable chiefly as so many keys to the secret of his extraordinary progress from obscurity to power and place. "Coningsby," "Sybil," "Tancred," "Lothair," and "Endymion" possess permanent interest for every student of nineteenth century politics.

Mrs. Gaskell and Others. Between Disraeli and the next great figure on our list comes the names SAMUEL WARREN (b. 1807; d. 1877), the author of "Passages from the Diary of a Late Physician" and "Ten Thousand a Year"; ANNE MANNING (b. 1807; d. 1879), who wrote a series of tales of sixteenth century life; PHILIP MEADOWS TAYLOR (b. 1808; d, 1876), the author of several capital tales of Indian life, including the "Confessions of a Thug"; and ELIZABETH CLEGHORN GASKELL (b. 1810; d. 1865). Mrs. Gaskell's "Mary Barton," a story of factory life, and "Cranford" form a link between the work of Jane Austen and that of Charlotte Brontë, whose life Mrs. Gaskell wrote with conspicuous success.

The Two Aspects of Thackeray. WILLIAM MAKEPEACE THACKERAY (b. 1811; d. 1863) has to be considered, as Scott is considered, in two aspects—as a great novelist and as a great moral influence. No one who knows his Thackeray can ever misinterpret the meaning of the word "gentleman," or, with Thackeray in his mind, fail to distinguish the real from the sham in character or in sentiment. Thackeray has been lightly called a cynic. The word, applied to him, is wholly misused. No writer since Scott had so true or gentle a heart as Thackeray had, and his works are indeed, like Scott's, "a liberal education." At the same time there is a great deal of force in the contention that while Thackeray saw, loved, felt, and makes us love the higher, brighter, purer side of life, he had a surer hand when depicting what was base and artificial. For explanation of this we must look to the political and social circumstances of the time in which he lived and wrote, and to his peculiar sensitiveness to all around him. Thackeray was no cynic, but he is the greatest of English satirists, a man who gibbeted snobbery for all time, having first of all dissected its anatomy and laid its organs bare, and he must be judged as a purifying moralist while he is being judged as a historian and a novelist.

THE BRONTË SISTERS WRITING THEIR FAMOUS STORIES IN THE RECTORY AT HAWORTH

Thackeray's Realism. With Thackeray, *philosophy* first showed itself in English fiction; by the side of his work, what Lytton passed off as philosophy is seen to be mere affectation. Of Thackeray's novels, "Pendennis," "Esmond," and "The Newcomes" are unquestionably the masterpieces. They reflect life. As Professor Saintsbury says: "Every act, every scene, every person in these three books is real with a reality which has been idealised just up to, and not beyond, the necessities of literature. It does not matter what the acts, the scenes, the personages may be. Whether we are at the height of romantic passion with Esmond's devotion to Beatrix, and his transactions with the duke and the prince over diamonds and title-deeds; whether the note is that of the simplest human pathos, as in Colonel Newcome's deathbed scene; whether we are indulged with society at Baymouth and Oxbridge; whether we take part in Marlborough's campaigns or assist at the Back-kitchen—we are in the House of Life, a mansion not too frequently opened to us by the writers of prose fiction." Of the much-debated "Vanity Fair" it must suffice if we say that it admirably exemplifies Thackeray's creed, which, simply put, is that goodness, however it may be scorned, is its own sufficient great reward. One of the giants of English letters in the last century, it is, of course, unnecessary to insist that the whole library of Thackeray's works must attract the student and the general reader alike.

Charles Dickens. Before turning to the works of CHARLES DICKENS (b. 1812; d. 1870), the young student could not do better than read the "Life" of Dickens by Forster. Although often criticised, it is an excellent biography, ample in its information, intimate in its knowledge, and the reading of it is wonderfully stimulating. What multitudes beyond all computation have been helped to smile through their tears and to take their courage in both hands under the influence of the inimitable, imperishable humour of Charles Dickens! Dickens saw the soul of goodness in things evil; his was the saving grace of humour; and his books, appealing to a far wider circle than the works of Thackeray, are among the best examples English literature has to show of the novel with a purpose. Where Thackeray inspires our admiration, Dickens compels our love. He has enshrined in his wonderful portrait gallery not only the short and simple annals of the poor of a period happily now no more, but he has shown us the possibilities of goodness and of happiness even in the most unlikely circumstances and characters. He has moulded and fashioned common clay till we see its relationship to that which goes to the making of the finest porcelain. Through him the rich have come to understand the poor, and the poor have arrived at a clearer realisation of themselves.

Dickens's Merits and His Limitation. Dickens was "self-educated"; he had obvious limitations, but his absolute genius is even more pronounced than that of Thackeray, of whose pictures of high life Dickens's transcripts from humble life may be said to form a necessary counterpart. Indirectly, Dickens may be taken as a warning by the young writer. When Dickens, as in "Oliver Twist," wrote of what he knew, he fashioned for himself a permanent niche in the temple of fame. When, as in "Bleak House," he attempted to illustrate a phase of life with which he was unacquainted, he failed sadly. After reading the "Life" the student should read "David Copperfield," which is largely autobiographical. Of Dickens's novels it has to be said that they are chiefly tales of town life; that, in the main, their plots are indifferent, though he is not lacking in the element of drama; and that their success depends upon their character studies or "humours," as Jonson would have called them. As he wrote so largely of social conditions which have passed away, later generations may find their interest in his works less readily excited than was the case with our fathers, but his novels are among the imperishable possessions of our national literature, and command the attention of every student of English fiction.

From Reade to Kingsley. CHARLES READE (b. 1811; d. 1884), who, like Dickens, "wrote with a purpose," but who, unlike Dickens, was a scholar of no mean attainments, attacked prison scandals in "It is Never Too Late to Mend," private lunatic asylums in "Hard Cash," and coffin ships in "Foul Play." He has left us a vivid picture of industrial life in "Put Yourself in His Place," but his greatest book is indubitably "The Cloister and the Hearth," a mediæval romance based on the "Colloquies" of Erasmus. JOSEPH SHERIDAN LE FANU (b. 1814; d. 1873) was an Irish novelist with a strong bent towards the "uncanny." He wrote some sixteen books in all, of which "Uncle Silas" is perhaps the best. No one has excelled him in the writing of the ghost story; not even R. L. Stevenson could "achieve the grue" with such weird success as Le Fanu. ANTHONY TROLLOPE (b. 1815; d. 1882) should be approached first of all in his "Autobiography." His innumerable novels, of which "Barchester Towers," "Framley Parsonage," and "Orley Farm" are the chief, contain some charming studies of women, and represent very faithfully English clerical life. They are invaluable to the student of the Victorian era, and will almost certainly enjoy in the future far greater popularity than they have had since Trollope passed away. CHARLOTTE BRONTË (b. 1816; d. 1855) struck in "Jane Eyre," "Shirley," and "Villette" the first clear bell-note of modern English womanhood. Her work is part of her own pathetic life-story. EMILY JANE BRONTË (b. 1818; d. 1848) also displayed exceptional if morbid power in "Wuthering Heights"; and Charlotte's youngest sister, ANNE BRONTË (b. 1820; d. 1849), wrote two novels, "Agnes Grey" and "The Tenant of Wildfell Hall," which, while they gain in interest from their personal associations, vividly picture moorland scenery and the life of a governess. Before taking up the works of the three sisters, the student should read Mrs. Gaskell's classic "Life" of Charlotte Brontë.

and Mr. Clement Shorter's interesting little book on "Charlotte Brontë and Her Sisters." CHARLES KINGSLEY (b. 1819; d. 1875) was a follower of Frederick Denison Maurice and Thomas Carlyle, and a manly exponent of "muscular Christianity," or "Christian Socialism." His books possess the prime quality of stimulus, "Alton Locke" and "Yeast," in particular. "Westward Ho!" and "Hereward the Wake," fine historical romances, will always have a warm place in the hero-loving, adventure-seeking heart of youth. HENRY KINGSLEY (b. 1830; d. 1876), the brother of Charles, wrote several novels, chiefly of Colonial life. His masterpiece was "Ravenshoe," which deserves to be remembered with the best work of the author of "Westward Ho!" and in the judgment of some critics is superior to any of Charles Kingsley's novels.

A Great Woman Novelist. GEORGE ELIOT (MARIAN EVANS) (b. 1819; d. 1880) is one of the greatest of English women novelists. As was the case with Jane Austen, and even more the case with Charlotte Brontë, George Eliot put herself and her actual experiences into what she wrote. Her books are, for the most part, real, sincere, earnest. Her genius flowered late; some of her writings have the effect of finished buildings from which all the scaffolding has not been taken down, but her contributions to the novel of manners, and particularly of the rural life of her native Warwickshire, are of lasting and living merit. With George Eliot the writing of fiction was the art of thinking aloud, the novel was a form of philosophy; but in the forefront of her philosophy, which, like Carlyle's, was devotion to duty, her characters stand out with lifelike fidelity. She was influenced more, perhaps, than any other English woman writer has been by her foreign, and especially German, studies. The "Scenes of Clerical Life," "Adam Bede," "The Mill on the Floss," and "Silas Marner" display her genius at its best. "Romola," a story of the Italian Renaissance, will always have its admirers. It betrays scholarship of no ordinary kind, but it was brilliant task work, and its author said afterwards that she was a young woman when she began the book and an old one when she finished it. "Daniel Deronda," another piece of task-work, should be studied with Disraeli's "Tancred" by those interested in the mysteries of the Hebrew character.

Other Notable Victorian Novelists. We must mention Mrs. HENRY WOOD (b. 1814; d. 1887), authoress of "East Lynne"; Mrs. LYNN LINTON (b. 1822; d. 1898), who put much autobiographical material into her "Christopher Kirkland," and wrote one quite remarkable book in "Joshua Davidson"; CHARLOTTE YONGE (b. 1823; d. 1901), authoress of "The Heir of Redclyffe"; DINAH MARIA MULOCK (Mrs. Craik) (b. 1826; d. 1887), who wrote "John Halifax, Gentleman"; MARGARET OLIPHANT (b. 1828; d. 1897), whose life-story is, perhaps, more interesting than any of her novels; ADA ELLEN BAYLY ("Edna Lyall") (d. 1903), authoress of "Donovan"; GEORGE JOHN WHYTE-MELVILLE (b. 1821; d. 1878), who wrote well of life in the "shires"; THOMAS HUGHES (b. 1822; d. 1896), author of "Tom Brown's Schooldays"; WILLIAM WILKIE COLLINS (b. 1824; d. 1889), author of "The Woman in White" and "The Moonstone," models of a long line of detective stories; GEORGE MACDONALD (b. 1824; d. 1905), whose "Robert Falconer," "Alec Forbes," "David Elginbrod," and "Sir Gibbie" are full of the humour of Scottish life as seen by a devout Calvinist; JAMES PAYN (b. 1830; d. 1898), author of "Lost Sir Massingberd" and "By Proxy"; JOHN HENRY SHORTHOUSE (b. 1834; d. 1903), author of "John Inglesant"; WALTER BESANT (b. 1838; d. 1901), whose "All Sorts and Conditions of Men" prompted the People's Palace, and who collaborated with JAMES RICE (b. 1843; d. 1882) in "Ready-Money Mortiboy" and "The Golden Butterfly," the last-named of which contains many wholesome morals for the literary aspirant on the difference between doing work and thinking about it: WILLIAM BLACK (b. 1841; d. 1898), author of "A Daughter of Heth"; RICHARD DODDRIDGE BLACKMORE (b. 1825; d. 1900), who wrote nothing better than "Lorna Doone," a romance of his native Devonshire; GEORGE GISSING (b. 1857; d. 1903), to whom culture was no protection against the pessimism that is often the companion of poverty; and HUGH STOWELL SCOTT ("Henry Seton Merriman") (b. 1863; d. 1903), whose novels, though essentially melodramatic, are characterised by a genuine gift of observation.

Stevenson as a Novelist. ROBERT LOUIS BALFOUR STEVENSON (b. 1850; d. 1894) crowded many activities into a short life, but as a novelist he brought the greatest influence to bear upon contemporary literature. This influence was of a two-fold character. In the first place, it was the influence of a writer for whom form was a dominating concern; in the second place, the influence was that of one for whom the world was still young, and who, believing that to the young in heart all things are possible, succeeded by the exercise of his genius in reviving the latent spirit of romance. Stevenson was equally at home in dealing with the peculiarly horrible—witness "The Body-Snatcher" and "Dr. Jekyll and Mr. Hyde"; pure adventure, as in "Treasure Island," which first won for him the suffrages of a wide public, and "Kidnapped." In the serious work of novel writing, distinct from the short story, the phantasy, or the book for boys, Stevenson's gifts are seen at their best in "The Master of Ballantrae." The uncompleted "Weir of Hermiston" is sufficient answer to those who may be inclined to attach any credence to the fear felt by Stevenson, towards the close of his short life, that his powers were deserting him. He was equally a master of the novel and the short story. Yet he is likely to be remembered, in the years to come, at least equally for his essays.

J. A. HAMMERTON

State Prizes in India and the East. Indian Civil Service. The Forest Service. Eastern Cadetships. Police and Professional Appointments.

IMPERIAL SERVICE IN THE EAST

THE Imperial Service, which we are to consider in this and succeeding chapters, forms the last great division of our general subject, the CIVIL SERVICE. In many respects it is also the most attractive—at least, for that great race of "adventurous youth" whose passing certain pessimists among us have prematurely mourned of late. For the most part the Imperial Service offers a strenuous, eventful career in some far quarter of the globe, with greater hardships than attach to the rather monotonous life of official routine at home, but also with much greater chances of attaining to distinction and success.

Embracing, as it does, our numberless colonies, dependencies, and possessions, and comprising both State and municipal employment, the Imperial section is in itself fully as varied and comprehensive as the home services whose survey we have concluded. But it is important to bear in mind that while appointments in this service are in some instances accessible to candidates in Great Britain, many others are reserved for local patronage or competition. Particularly is this the case in our greater colonies, such as Australia and South Africa, whose civil officers of every grade are recruited almost entirely from local sources.

Where such conditions of employment prevail, an exhaustive description of the service would be useless. The course we propose to follow, therefore, is to discuss at length those posts for which British aspirants can enter, and to deal more briefly with the rest, while indicating the source from which fuller information as to these latter appointments may be readily obtained upon application.

INDIAN CIVIL SERVICE

Some of the finest administrative and judicial positions in the Indian Empire are brought within reach by success at the open competition held every August for probationary appointments in what is termed the "covenanted" Civil Service of India. The expression refers to the covenant, or contract, which every successful candidate has to execute with the Indian Government, and is used to distinguish this from a subordinate service that is filled chiefly by patronage in India.

For ambitious young students who are not daunted by the prospect of exile and a trying climate, the "I. C. S.," as it is generally called, offers prospects far more brilliant even than are afforded by Class I. clerkships in the home service, which have already been described.

The examination is open to all natural-born subjects of his Majesty (including Indian natives) who are between 22 and 24 years of age on August 1st of the year in which they enter. No deduction of age on account of military or other service is permitted for these posts. As already explained [see First Class Clerkships, page 2055], a joint competition is held for the Indian Civil Service, Eastern cadets, and clerks in the home service, eligible candidates choosing, in their order on the combined pass-list, which service they elect to enter.

The official regulations as to these annual contests may be had on application to the Secretary, Civil Service Commission, Burlington Gardens, W. On the subjects prescribed, and the very searching character of the papers, nothing can usefully be added to the information given on page 2055.

"Selected Candidates." Successful competitors who choose the Indian service are known as "selected candidates." They are on probation in England for a year, studying Indian law and history and the language of the province to which they are assigned. An allowance of £150 is granted to those who spend this term at a university or college approved by the Secretary for India. The probationers must then pass an examination in their studies, the cost of failure being withdrawal from the service. They are also tested in horsemanship.

Selected candidates who acquit themselves creditably at the final test are provided with a free first-class passage to India, and on arrival receive appointments at a salary beginning at 4500 to 5000 rupees per annum. Taking the average value of the rupee as 1s. 4d., this represents about £300 to £330 a year. The actual value is usually somewhat higher. The conditions of employment are generous, every year of actual service entitling the young civilian to three months' furlough, which may be accumulated to permit of a prolonged visit home. After a time the officer is called upon to choose which branch of the service he will follow—the judicial or executive. The former may lead him eventually to a judgeship in the High Court, the latter to the rank of Lieutenant-Governor of a province.

Apart, however, from such great prizes as these, opportunities for obtaining distinction are not wanting in the service; and if the individual has the ability and energy to seize them, his advancement is likely to be rapid. Many members of the I. C. S. reach responsible and highly paid positions, such as that of judge or magistrate of a native court, while still young in their calling. After a quarter of a century—21 years of which must have been effective service, as distinguished from furlough and sick leave—the Indian Civil servant is entitled to retire on a life pension of £1000 a year. Ten years later his retirement becomes compulsory under the regulations.

EASTERN CADETSHIPS

These positions have been instituted to supply the higher ranks of the Civil Services of Ceylon, Hong Kong, the Straits Settlements, and the Federated Malay States with trained and capable officers. They are filled by open competitions held every August concurrently with those of the Indian Civil Service and for Class I. posts, but their inferiority in value is shown by the fact that they generally fall to men low down on the combined pass-list, higher-placed candidates having selected the other services in preference. Thus, at a recent joint contest, the first man to accept an Eastern cadetship had taken only the 37th place on the list. Still, these posts are distinctly attractive ones, with a fair salary from the outset, and good, though not dazzling, prospects.

The examination subjects are the same, of course, as for Class I. appointments [page 2055], and the same age limits are fixed, namely, 22 to 24, but for cadetships no deduction from actual age is permitted. Candidates must be of sound constitution and good eyesight, and fit for tropical service. Except for Ceylon, it is specified that cadets shall be of European descent.

Selected candidates are required to leave England about a month after passing, and receive a free passage, half-pay on embarking, and full salary on reaching their destination. In Ceylon their remuneration as cadets is £200 a year without quarters; in Hong Kong, £225 with a house allowance; and in the other colonies £250, with furnished quarters. The routine of training is practically the same in all cases, the cadet dividing his time between his studies in the native tongue and instruction in Government business. On passing his examinations he receives an immediate advance of pay—in Ceylon to £350, elsewhere to £300—and becomes eligible for a permanent appointment with a salary usually beginning at £400 a year. Thence, as he rises in grade, his income progresses to £900 or £1000 at the least; and there are further possibilities before him, leading to a salary of £1500 or £2000.

INDIAN FOREST SERVICE

A hardy young fellow in quest of an open-air calling, and undismayed by exposure and fatigue, could scarcely find a more tempting career than is afforded by the Forest Service of India. It involves much lonely service in the remoter regions of our great Eastern Empire, often far from white men; but to those who have heard "the call of the wild," and cannot forget its voice, there are ample compensations in the eventful, unhackneyed days passed amid some of the grandest and most beautiful scenery in the world.

One essential feature of the Forest Service is the costly training that precedes it, for which a private allowance of about £100 a year for two years is necessary. Many likely men are debarred by lack of the requisite means, and thus it arises that, despite its attractions, the number of applicants for vacancies in the service is not, as a rule, very great.

No entrance examination is held unless the number of fully qualified candidates between the ages of nineteen and twenty-two exceeds the number of vacancies, in which case there is a limited competition, mainly in the natural sciences. Otherwise, the claims of applicants and their educational record are considered by a Selection Committee, who advise the Secretary of State for India as to the most promising candidates. An honours degree in natural science, or some equivalent degree, is essential, and a fair knowledge of French or German is also required of the candidate.

Probationers. Selected candidates are required to pass a strict medical examination, at which particular stress is laid on good vision and hearing. They are then appointed on probation for two years' training. During this time they pursue a special course of study at Oxford, Cambridge, or Edinburgh University in forestry and allied subjects, receiving from the Indian Government an allowance of £120 a year meantime, but defraying all expenses not covered by this grant. During the vacations they receive free practical instruction in the subject of their future calling, visiting various Continental forests for the purpose.

On completing their training, probationers who have obtained the degree or diploma of Forestry are appointed assistant conservators in the Indian Forest Department, and proceed to take up their duties. They must take their own passages for India, but receive an official allowance to cover the cost.

Pay and Prospects of Conservators. From the date of their arrival in India, assistant conservators draw 380 rupees a month (about £300 a year). They are appointed to one of the great timber divisions—Burma, Assam, the Punjab, or elsewhere—and are entrusted with the protection and improvement of the forest land within their section, the reafforestation of denuded areas, and similar responsible and interesting work. Their pay is augmented yearly by 40 rupees to 700 rupees a month, and afterwards by 50 rupees to 1250 rupees a month—which figure is attained in the twentieth year of an officer's service.

The higher ranks are remunerated as follow, the figures being given in rupees per month: conservators, 1500 to 1900; chief conservators, 2150. There are a few leading posts at still higher remuneration.

The official regulations as to these appointments, with particulars of salaries and pensions and a syllabus of the possible entrance examination, may be obtained on application to the Secretary, Revenue Department, India Office, Whitehall, S.W.

POLICE APPOINTMENTS

Although police duties are vastly less interesting than forestry to the normal mind, the examination for the Police Service of India and the Further East attracts a great many more candidates every year than seek to enter the Forest Service—and this for a sufficient reason. Admission to either service is followed by a term

of probationary training; but whereas the future conservator of forests, as we have seen, has to study hard for two years before earning a rupee, the police probationer is receiving over £240 a year within three months after passing his entrance examination.

As in the case of the cadetships already discussed, a single examination is employed to recruit several police services. The competition is an open one, and is held every June, or thereabouts, for such vacancies as then exist in India, Hong Kong, the Straits Settlements, and the Federated Malay States. Candidates may enter for all appointments at the same time on payment of a single fee of £2 (or £3 if examined elsewhere than in London); and are required, if successful, to make their selection as soon as the result of the competition is announced. By far the greatest number of vacancies arise in the Police Service of India.

The Examinations. Unlike most open Civil Service examinations, these competitions are not advertised in the public Press. Applications to compete must be made not later than May 1st of each year, on a printed form obtainable from the Secretary, Judicial and Public Department, India Office, S.W. Candidates must be unmarried, and between the ages of 19 and 21 on June 1st of the year in which they compete.

The examination is in English, elementary mathematics, French or German, and history and geography, and not more than two of the following subjects: intermediate or higher mathematics, Latin, Greek, a second modern language, history, and science—to each of which a maximum of 2000 marks is assigned. Candidates may also take up freehand drawing, which carries only 400 marks.

Those who are successful at the literary contest must next undergo a strict medical examination as to their physique and capacity for active outdoor work on the plains of India or elsewhere. On satisfying the Civil Service Commissioners of their ability to ride, they are then appointed as probationers at one of the districts in which a vacancy exists, their wishes on this point being consulted as far as practicable. They are provided with a free passage out, and must be ready to embark in the October following the examination.

A probationer who is sent to India receives 300 rupees a month while under instruction in police duties and in the local language. On passing certain examinations in these subjects—a task that must be achieved within two years of his arrival in India—he is appointed Assistant Superintendent of Police at the same rate of pay, rising to 500 rupees monthly, and has excellent chances of becoming District Superintendent, with a salary of 1200 rupees per month. There are also a few higher posts within his reach. In the other services probationers are paid £225 a year on arrival, and £300 after passing the departmental examinations. On receiving an appointment they draw a salary of £350, rising to £660, and, if fortunate, may reach £1000 a year. Free quarters are provided for probationers and for officers of all grades.

Subordinate Posts. For the most part, the police rank and file in the East are native officers. In Hong Kong, however, there is a British force which is largely recruited by volunteers from the home constabulary. Police constables are engaged for five years or longer, and are paid £100 a year, rising by triennial increments of £10 to £120, with free quarters. A bounty of £15 is paid on enlistment. For proficiency in Chinese they may receive a further allowance. Candidates must be unmarried, not less than 18 nor more than 25 years old, at least 5 feet 8 inches in stature, and with a minimum chest measurement of 33 inches. Previous police experience is desirable but not essential. Promotion is said to be no faster than in the home forces, the sergeant's stripes taking six or seven years to win. Forms of application for the Hong Kong police can be obtained from the Crown Agents for the Colonies, Whitehall Gardens, S.W.

OTHER INDIAN APPOINTMENTS

In addition to the services already discussed, there are others for which only those candidates are eligible who have been specially trained in one of the professions. Such appointments have little interest for a student of this course, their place being among the professional groups of the SELF-EDUCATOR. For present purposes they may be dismissed in a few words of description.

Public Works and Telegraphs. Trained engineers from the universities and technical colleges are eligible for valuable appointments in these services if between 21 and 24 years old. There is no entrance examination, candidates being selected on their scientific attainments. Salaries range from 4500 to 33,000 rupees a year. The regulations can be obtained of the Secretary, Judicial and Public Department, India Office, S.W.

Veterinary Posts. Candidates possessing the M.R.C.V.S. diploma have a chance of entering the Indian Civil Veterinary Department on attaining the age of 26. The pay and prospects in this service are good, but officers are debarred from private practice.

Education and Nursing. Appointments in the Indian Educational Service are under the patronage of the Secretary of State, who usually awards these to distinguished graduates of British Universities. No limits of age are prescribed. Officers are engaged in the first instance for a term of five years, at an annual salary of 6000 rupees, rising by 600 rupees yearly to 8400. There are good prospects of promotion if the period of engagement is extended for another term.

Trained nurses between 27 and 32 years of age are appointed by the Secretary of State to Queen Alexandra's Military Nursing Service for India, for a term of five years in the first instance, on terms that can be obtained on application to the Military Secretary, India Office, S.W. The rates of pay are 2100 rupees yearly for the first five years, 2400 rupees subsequently, and 2700 to 3600 rupee in the senior grades.

ERNEST A. CARR

The Complete Failure of Mendelism to Solve the Most Vital Problems of Evolution.

THE LIMITS OF MENDELISM

THE time has come when we should face the question of the relation of Mendelism to the supreme problem of organic evolution. The student of this course is fully aware of the distinction, unknown to the careless many, between the assertion of organic evolution as a fact and the explanation of it. Here we know that the last century proved the fact, which can never henceforward be in dispute. The explanation remains to find, unless we accept the theory of natural selection as such. The question for us now is whether Mendelism solves the riddle, or contributes to its solution, or affects in any way our estimate of previously proffered solutions. And the reason why we attack this question here and now is that the many certain and priceless triumphs of Mendelism in the last decade, the fame won by its exponents, and the signal failure of the attempts to discredit them, are all likely to hypnotise them and us into the belief that here is the whole truth at last.

Professor Bateson's Position. The subject of this chapter is the subject of the forthcoming presidential address to be delivered to the British Association in Australia in a few weeks from the time of writing by the president-elect, Professor Bateson, the living master of Mendelism. Here we shall anticipate the main features of that address, citing first Professor Bateson's recently published Yale lectures on "The Problems of Genetics," and, second, his final lecture as Fullerian Professor of Physiology at the Royal Institution, delivered on May 12, 1914, under the title "The Present Aspect of Evolutionary Theory." If Professor Bateson himself now formally repudiates the idea that Mendelism has solved the problem of organic evolution, all casual impressions as to the real nature of its contribution will be justly dispelled.

In 1908 Professor Bateson spoke too generally. He said, in a passage we have already quoted, that a certain Mendelian experiment "demonstrates at once the nature of variation and reversion." Later, in the same inaugural lecture, he used the following oft-quoted words, which the student must carefully note: "For the first time *variation* and *reversion* have a concrete, palpable meaning. Hitherto they have stood by in all evolutionary debates, convenient genii, ready to perform as little or as much as might be desired by the conjurer. That vaporous stage of their existence is over, and we see variation shaping itself as a definite physiological event, the addition or omission of one or more definite elements; and reversion as that particular addition or subtraction which brings the total of the elements back to something it had been before in the history of the race."

Reversion Illustrated. The typical instance of this assertion is the famous case of Darwin's pigeons. Two modern forms, when crossed, yielded the blue rock ancestor of all modern pigeons, or, at least, a closely similar bird. The reversion to the ancestral form here means, as in the case of Bateson's sweet-peas, that certain factors, which were combined in the blue rock pigeon and separated in its descendants, have come together again; reversion, that long mysterious fact, now has a "concrete, palpable meaning."

Here, beyond doubt, is a substantial and permanent addition to knowledge. We can never think of reversion again, or meet the word, without remembering these Mendelian facts; and the same is true of the word "variation," which the Mendelian shows to mean "the addition or omission of one or more definite elements." But it were better not to acquaint ourselves with these facts at all than to suppose, as Bateson did six years ago, that *all* variations and *all* reversions are thus explained. The generalisations we have quoted are far too general, and they entirely ignore, as we shall see, the real *crux* of the problem, which Professor Bateson has since more clearly realised, and before which he confesses Mendelism to be impotent. These statements are of the very highest importance, and the student is besought to weigh them accordingly.

The Present State of Evolutionary Theory. Six years ago the assertion was that Mendelism had explained variation and the origin of variations. If that were so, the problem of organic evolution, the problem of the origin of all the living forms we know, would be solved—the riddle of creation would have been read. Hear now, incorporated in the present writer's own statement of the case, what the same authority is saying in his recent and forthcoming pronouncements of the present year; and then we shall realise, in a single, simple phrase, the nature of the problem that remains, and shall see it to be the old riddle, *untouched in any degree*, but merely asked in new terms.

The present state of evolutionary theory, as compared with the dogmatic Darwinism and neo-Darwinism of the nineteenth century, shows merely a vast *negative change*. In the practical, constructive art of forming new species Mendelism excels, but its rôle for theory is that of destructive criticism merely. Much that seemed perfectly simple to Huxley we now find ourselves entirely ignorant of. Yet Huxley was not a hasty dogmatist. It took years to persuade him of the importance of natural selection. He was a genuine student, fully worthy of his high honour as President of the Royal Society.

Twenty-one years after the publication of Darwin's "Origin of Species," Huxley gave a lecture at the Royal Institution on the "coming of age" of the theory of natural selection, which that book gave to the world. He and the scientific world in this country—though by no means on the Continent or in America—were fully persuaded that natural selection explained organic evolution.

Today, thanks to the experimental facts which were then unknown, we see that the whole basis of the Darwinian theory was insecure. It assumed that all species are constantly varying in all directions, and that the necessary survival of the fittest means the natural selection of the fittest, or most viable, of those variations, with the subsequent transmission of them to succeeding generations by heredity.

The Fall of the Variation Theory. When we take a given case and examine it, we find that the supposed variations do not occur. The most celebrated experiment in this matter was made now more than a decade ago, by the Danish botanist Professor Johannsen, of Copenhagen. Studying beans, he showed that selection soon ceased to effect any change in the natural characters of the race, for the simple reason that selection can create nothing, and that the genetic nature of the beans limited with absolute sharpness their powers of variation.

For one generation or two, the selection of the heaviest (for instance) seems to be leading towards a heavier race—and then the internal facts said, "Thus far and no farther." No subsequent selection did anything simply because the assumed indefinite variations for selection to select from did not occur.

And so in all other cases. Variation is not what Darwin and his contemporaries thought it, and, that being so, the whole Darwinian theory falls to the ground. The present writer is not aware of the name of a single student in any part of the world, now actually adding to our knowledge of these problems, who accepts the Darwinian explanation of evolution. In the light of modern genetics, the whole of that famous structure is seen to be merely a brilliant phantom of the imagination. By an unfortunate consequence of the working of things, the public mind has now just caught up with nineteenth-century science enough to accept natural selection and Darwin as the explanation of everything, when the worlds of science and philosophy know that Darwin's sole though ever-glorious merit was merely to demonstrate what the future has yet to explain.

A Restatement of the Question. In this work a special effort is being made, of set purpose, to present the student with biology as it is today, and not as all but its active contemporary students suppose it to be. Within recent years the country has been flooded with almost incredible quantities of cheap reprints of nineteenth-century classics, which are supposed to represent the last word on the science of life, and which are nearly all tainted with the bitterness or the dogmatism which were bred in men of science in that period by the outrageous presumption and insolence of ecclesiasticism. Huxley, Tyndall, Clifford, Spencer, Darwin, Haeckel—these writers have contributed, in varying degree, to the imperishable history of the science of life. Many of their writings are classical now, as Aristotle is classical; but, thanks to Aristotle and to them, we of today know more and better than any of them. It is, in reality, the worst of services to such fearless seekers after truth that their beliefs about evolution should be looked at as final and immutable products of a universe which is haply evolving still. That is why only one chapter has been allotted to Darwinism, though, in the popular view, the whole of our subject is Darwinism, and though, so lately as ten years ago, Darwinian assumptions dominated such expositions.

Natural Selection, Natural Rejection. Natural selection, as Johannsen and many others have proved, cannot make a species "budge" if it does not mean to budge anyhow—that is, if it is not producing the necessary variations. The idea of natural selection arose in order to explain adaptation. The idea of a Divine Manufacturer, somewhere in the sky, having *made* these adapted forms of life in the Garden of Eden, six thousand years ago, vanished before the record of the rocks; and the hope was that the facts of adaptation could be explained by a mechanical process, assuming endless fortuitous variations, and the survival of the fittest—that is, the best adapted—of them. But today we know that there are countless adaptations in the living world for the explanation of which natural selection is not merely inadequate but wildly ridiculous. Even assuming that the necessary variations occurred, natural selection would not explain the facts, and, in any case, natural selection can only act on what is there. It is, and should be called, merely *natural rejection.*

Mendelism no Explanation of Adaptation. Does Mendelism, on the other hand, help us with adaptation? The Darwinian explanation has been found insignificant; what have Mendelian theory and the now immense accumulation of Mendelian facts to offer us instead? *Nothing at all*, is the answer. That is not the opinion of an enemy or even of an impartial and detached critic. It is the definite conclusion of Professor Bateson himself, and those who know somewhat less of the subject than he will do well to be guided by it. By all means let us be grateful for Mendelism, honour it, learn from it, and apply it, as it can be applied, to the central problems of national life—such as the quality of a people's food, and the quality of those whom it feeds—but let us understand that, as an explanation of the world-wide facts of the adaptation of living organisms to their environment, Mendelism is beside the point. Even natural selection, which at least explains the extinction of the less adapted, is worth more to us than Mendelism for this purpose.

Whence come Purpose and Adaptation? Yet, be it remembered, adaptation is the central fact we have to explain. The exquisite structure of the eye which now reads these words, *for the purpose of seeing*, is typical of the whole

world of life. If the eye was not so made from without by Deity, but was evolved through countless ages, from simpler forms, until we get back to a mere pigment spot in the skin chemically sensitive to light—which we know to be the historical fact—the science of evolution is required to explain the present manifold exquisiteness of the adaptations by which the eye now sees. Professor Bateson himself, an uncompromising supporter of the mechanical or physico-chemical theory of life, avows that Mendelism does not help us to an answer, and he and many others have shown that Darwinism fails also. Does not the reader see the immense significance of these developments and admissions, and the tremendous presumption they raise that modern Vitalism, as represented by Bergson and Driesch and MacDougall, alone has the solution ?

Here, in Mendelism, we have the newest, and certainly the truest, of the physico-chemical theories of life and of heredity. According to it, certain physico-chemical entities, called "factors," determine the life of all that live. Every quality, every attribute, every faculty, that man, or any animal, or any plant, possesses becomes, in the light of these conclusions, the mere result of the action of certain chemical compounds found in germ-cells. Before we accept this as the whole of the truth, let us remember the central, crucial fact of adaptation, which this newest of materialistic theories is as impotent as any of its predecessors to explain, according to its own champions, who have, indeed, thus performed for Vitalism the theory that life is Purposeful Mind incarnate—the important service of destroying the materialistic theory called Darwinism, without attempting to replace it by any other. So much the more is justified the importance which we attached, in earlier chapters of this course, to the works of Bergson there briefly referred to.

Mendelism: An Explanation of Some Negatives. But, putting aside the facts of adaptation as still insoluble by any mechanical explanation, what of the new light which Mendelism has admittedly thrown upon variation ? We see—for the fact is proved—that certain variations are due to novel combinations of Mendelian factors. Especially we find clear and satisfying explanations for all those cases of variation which correspond to what we have learnt to call "Mendelian recessives." For what, on Bateson's beautiful and simple explanation of Mendel's law, is such a variation ? It is merely due to the dropping out from the germ-cells of a factor present previously. When that factor is thus absent, the new organism displays a new character, which we call recessive. Hosts and hosts of variations are thus satisfactorily explained—the new form is simply due to the disappearance of something which was contained in the old. Similarly, hosts and hosts of new forms, or of the reappearance of old forms from new parents, are explicable by Mendelism, clearly and conclusively, and by Mendelism alone; factors have been combined in novel fashion, or else in fashions which long ago were common, but the ways of the factors have lain apart until, now; they meet again, and, lo! the ancestral form reappears. Nothing could well be more satisfactory, and our quotation from Professor Bateson's lecture of 1908 seems justified—almost.

The Silence of Mendelism on Origins. Professor Bateson has merely explained those forms of variation which depend upon shufflings of factors *already existing. The origin of those factors is yet to seek.* Recessives are all explicable, but "the origin of a dominant" remains unread. That is the short phrase referred to earlier in this chapter. Where does any dominant character come from ? In other words, where does any Mendelian factor come from ? *Given the factors,* modern Mendelism can offer us complete and satisfactory explanations in indefinite number. But the creative powers of evolving Life, supremely illustrated in men of genius, remain unexplained. The Mendelians have been assiduously searching and studying the living world for a decade, and have found innumerable new facts, but, as Professor Bateson said himself in May, no case is known of variation due to the addition of new factors. The Mendelian, wonderful and valuable person that he is, merely juggles with what is already given. Not a whisper of "creative evolution" is to be had from him.

Vital Purpose Unexplained. Mendelism offers us an explanation of the origin of nothing except what is merely a *minus* quantity—due to the disappearance of something previously present. From the first syllable to the last, Mendelism assumes and requires the existence of "factors." Given them, it does wonders, of which Professor Biffen's wheats are merely a preliminary example. Similarly, the chemist does wonders in the synthesis of atoms, to form new compounds, but he can tell us nothing as to the origin of atoms. The problem of biology is to tell us the nature of life and the way in which it evolves. On these questions, properly considered, Mendelism is silent. Nor must our analogy with chemistry mislead the reader. The chemist may at any time be able to make or destroy atoms, according to mechanical laws. But living beings exhibit Purpose, which is an attribute of Mind, and therefore non-mechanical. It seems clear, therefore, that the countless adaptations in which Vital Purpose expresses itself can *never* be explained in mechanical terms. That Professor Bateson himself should now be trying to do so is only one more illustration of the fashion in which special studies close the mind to general principles. Let us see the almost incredible fashion in which this process is now illustrated.

The Theory of Growth by Inhibition. "The origin of a dominant" being insoluble, and no instance even of its occurrence having been found by Mendelian research, one conceivable hypothesis remains. Some new forms of life certainly arise as recessives by the disappearance of dominants—that is, of positive factors—previously existing. Why should not

the whole of evolution have taken this course? It can be argued that the appearance of any new form is due to the disappearance of an inhibiting factor present in its ancestors. In sweet-peas and many other species, we know that the appearance of certain colours and other characters may be due to the dropping out of a factor which inhibited or prevented the action of other factors lying beneath it. Let us argue from these facts, and we may assume that *all* new forms of life have arisen by an evolutionary process which consisted in the dropping out of inhibitory factors present in the progenitors of the species.

This theory, indeed, has been and is seriously advanced by Professor Bateson, as the only alternative to "mysticism." In conversation with him, the present writer asked whether he would go as far as the theory required, and assume that the primitive amœba has become man by the successive dropping out of inhibiting factors in the absence of which, man appears. If now we walk round the Zoological Gardens, so as to give ourselves some faint idea of the multitudinous variety of living beings, we must further argue that all these, and all the other forms that have existed in the past, were unfolded from the primitive animal form—which we call amœba, for argument—by the dropping out of inhibitory Mendelian factors. And this is the alternative to mysticism!

The Bankruptcy of Materialism. It is, rather, the stark and utter bankruptcy of materialism—no mere confession of failures, no acknowledgment of the difficulty of the problem, no other theory that anyone is likely to be able to invent, could so completely display the nakedness of the land as this which explains Shakespeare and Newton and Wagner by the dropping out of factors which inhibited the microscopic amœba from writing "Hamlet." But more. For the sake of the argument we may admit this new theory of evolution; but the first child to whom we retail it will ask the obvious question—And where did the amœba get all these things from? Obviously, there is here no answer to the question of the origin of the countless beauties and wonders of the living world. They are simply rolled up and compressed, and laid in an invisible heap upon the back of the amœba, and we are merely faced with the original problem in a monstrous and egregious and palpably unnatural form.

The Mystery of the Dominant. "The origin of a dominant" remains for us to discover; and certainly the world of thought is indebted to Professor Bateson for the absolute and frank honesty with which he tells us that all the researches of himself and his school have failed to show a single instance of such origin, howsoever effected, and that no vestige of an idea as to how any dominant can arise is afforded by any of their observations. A "dominant" is a positive factor, an entity of some kind in the germ-cell, which causes the development of the eye or the brain, or the leaves, or the maternal instinct, or anything else in the living being. The Mendelian asserts, and we are all compelled by his evidence to believe, that in reality all the characters of living beings depend upon the determining and formative power of these factors in the germ-cells, from which all but the single-celled organisms arise. But now he formally tells us that of the origin of any one of these factors, in any one case, he is unable to tell us a word. In short, the whole problem of organic evolution remains, in all essentials, untouched by Mendelism. This new study has overthrown the pretensions of another mechanical theory to account for organic evolution, and offers us nothing in its place except the fantastic notion which we have quoted, and which is obviously worse than nothing.

Unnatural Divisions of Nature. Yet let us remember the famous observation of Bacon that the great art of knowledge consists in "rightly putting the question to Nature." We may be certain that we shall never get the real answer until we rightly ask the question, and every advance in knowledge helps towards this end. Mendelism assuredly does so in one important particular, upon which Professor Bateson rightly insists. "The Origin of Species" was the subject of Darwin's inquiry, and the title of his great book expresses an idea long fundamental in biology. We owe it chiefly to the great systematist Linnæus—really a Swede, named Carl von Linné. This profound and indefatigable student endeavoured, with invaluable success, to reduce the living world to some kind of order or system. He divided all living things into classes, according to their resemblances and differences. The smallest subdivision but one he called a genus, and the smallest a species. The scientific or Linnean name of any species is thus a double one, the first word indicating the genus, and the second the species. Thus we speak of *Musca domestica*, the domestic fly, or *Homo sapiens*, modern man, assumed to be wise. The first name is the generic, and the second the specific name. The Linnean system has been invaluable, and has helped incalculably towards the mapping out of the living world, and the study of the relations between its various forms. But there have always been difficulties. Many varieties are often found within one species, and many individual differences within a variety.

Disappearance of Catchword Divisions. When breeding experiments are made, and we see how each individual depends for its characteristics upon the combination of factors in the germ-cells, and how such combinations are infinitely various, and when, further, many species are found to be fertile when crossed, and their progeny fertile, too, the whole Linnean conception of species, as immutable and separate entities, vanishes for ever. No one, again, would dream of giving a book such a title as the "Origin of Species." Mendelism at least clears away a great accretion of names and stereotyped ideas which cumbered the ground. It is something to have the old question of questions stated again as "the origin of a dominant," even though positive science offers no hint of an answer thereto.

C. W. SALEEBY

Distributing Financial Risk. The Companies Acts. Memorandum and Articles of Association. The Prospectus and Underwriting.

THE FORMATION OF A COMPANY

The astonishingly rapid growth of modern business enterprise is due in an overwhelming degree to the famous Companies Act of 1862, which gave security to the investor by limiting his liability to the amount of his share or shares in the registered company of which he was a member. Before this great Act a shareholder was liable to his last penny for the debts of the company, and many cases are on record of men being absolutely ruined and stripped of every asset they possessed, because they owned a single share in a company that had failed. The passing of the Companies Act, by saving investors from this terrible risk, made available a vast deal of money for commercial enterprise, and gave an impetus to trade of which the British nation took full advantage. It is true that the Act led to a considerable amount of dishonest speculation, but the disadvantages were far outweighed by the benefits conferred on trade generally.

A former Chancellor of the Exchequer, Lord St. Aldwyn, has balanced up the pros and cons admirably. "People have a habit," he said, "of fixing their minds on petty details of company delinquencies, leading them to an irrational denunciation of the entire joint-stock system. Promoters and company-mongers do make illicit profits; shareholders do lose their money; prospectuses are misleading; directors do accept their qualifications from promoters when they ought not, and do try to hush up discreditable transactions. The yearly wreckage of the United Kingdom seems very terrible until we compare it with the whole vast volume of British shipping; so does company wreckage until we compare it with the vast joint-stock enterprise. It is the joint-stock system, with the co-operative enterprise, which has by the magic key of limited liability unlocked a golden stream of national wealth, and has done more than anything else in our time to stimulate and extend vast industrial undertakings which, without its aid, would have been Utopian and impossible."

In the last fifty years considerably more than a hundred thousand limited liability companies have been registered in England, and at present there are at least forty thousand of these companies doing business, their paid-up capital aggregating nearly two thousand millions sterling. It is a mistake to suppose, as some do, that only large businesses, or comparatively large ones, can be turned into limited liability companies. Quite a number of companies have been registered with a capital not exceeding two hundred pounds. The amount of capital actually raised, too, need not be anything like so much as the authorised capital that is legally allowed to be raised. At least one company has been registered with an authorised capital of a hundred millions sterling, but the paid-up capital has never exceeded a hundred pounds. Then the shares may be issued of any value the promoters think fit. A company registered in 1891 had a capital of one thousand pounds, divided into 9,600,000 shares of a farthing each, and the total number of shares subscribed was seven, valued at a penny three-farthings.

An advantage that has resulted from the principle of limited liability is the way in which the area of risk in business operations is spread. Under the old partnership plan, with unlimited liabilities, a few men, no matter how rich, might be ruined by the mistakes or fraud of a partner. Now, with the large number of shareholders that most compaines have, and the limitation of their liabilities to the amount of their shares, any financial failure is participated in by all the shareholders and all the creditors, the liabilities of each being smaller in proportion than they were when misfortune overtook business men under the old unlimited liability principle.

Many of the great commercial enterprises of today—great engineering operations, great catering businesses, universal stores, and so on—would have been impossible without the Companies Act, for only when the liability of investors is limited

to the amount of the shares they take up can people be induced to provide the capital for these enterprises. It is the co-operation of the many small capitalists that has enabled the enterprise of British commercial genius to bring about results that have been the admiration, and have called forth the emulation, of the world.

From the passing of the famous Companies Act of 1862, down to the beginning of the present century, a number of modifying and additional Acts were passed, and to know and understand these thoroughly was a work needing much ability and application. So complicated had the law become that it was felt something must be done to codify the various statutes, and in 1908 the Companies (Consolidation) Act was passed, which now contains all the law relating to companies, and has superseded the many earlier statutes. Anyone whose aim it is to be a secretary of a limited liability company must get a copy of this law, and study its various provisions if he hopes to be efficient at his work; and so many are the pitfalls into which a secretary may fall that the man who knows his business thoroughly may always be sure of earning a good salary.

There are, of course, a few companies still existing with unlimited liability, and other companies are occasionally formed by royal charter, letters patent, or under special Acts of Parliament; but as the great bulk of the business of the country is now carried on by limited liability companies, it is with these that we shall deal. Since the coming into force of the Companies Consolidation Act of 1908, there have been two kinds of limited liability companies—private companies and public companies. In order to relieve small companies with few shareholders, particularly such as those in which the shares are held by members of a family or a few personal friends, the Act has freed such small companies from some of the regulations which bind public companies. Among their special privileges are the following: They may register and carry on business with a minimum of two members; they need not include their balance-sheet in their annual summary; they need not forward and fill a statutory report before the annual meeting; they are not obliged to file with the Registrar a statement in lieu of a prospectus, as must the public company; they need not supply balance-sheets and auditors' reports, or give facilities for their inspection to preference shareholders; they need not obtain a certificate entitling them to begin business; they are exempt from restrictions as to minimum subscription on first allotment of shares; and they are saved from certain restrictions on the appointment of directors. According to the 1908 Act a private company is a company which by its articles restricts the right to transfer its shares, limits the number of its members to fifty (exclusive of persons in the employment of the company), and prohibits any invitation to the public to subscribe for any shares or debentures of the company. A private company, however, subject to anything contained in the memorandum or articles, may by passing a special resolution and by filing with the Registrar of Companies such a statement in lieu of prospectus as the company, if a public company, would have had to file before allotting any of its shares or debentures, together with such a statutory declaration as the company, if a public company, would have had to file before beginning business, turn itself into a public company.

Public companies are, of course, the ordinary limited liability companies, usually, though not necessarily, with a considerable number of shareholders, and include all companies but those specially referred to above. The description "public" is used because these companies make a public issue of their shares. Any seven or more persons may combine to form and register such a company.

In order to have a company incorporated in England it is necessary to file with the Registrar of Joint Stock Companies, at Somerset House, in London, a memorandum of association, articles of association (if there are any), a statement of the nominal capital of the proposed company signed by an officer of the company, the situation of the registered office of the company, a statutory declaration of compliance with the Companies Act, and a list of persons who have consented to act as directors of the company, with a form of consent signed by each. Scottish companies are registered in Edinburgh; Irish companies at Dublin. The memorandum of association must be drawn up with care, as it is difficult to alter it after registration. It is signed by the original

members of the company at the date of its incorporation, and must contain, according to the Act, the name of the company, with "limited" as the last word in its name, whether the registered office is to be situated in England, Scotland, or Ireland; the objects for which the company is established, a declaration that the liability of the members is limited, the amount of the share capital with which the company proposes to be registered, and the number of shares of a fixed amount into which it is to be divided. No subscriber of the memorandum may take less than one share, and each subscriber must write opposite to his name the number of shares he is taking in the company.

Articles of association are the rules governing the management of the company, and must be drawn up on certain principles prescribed by law. Many companies, however, do not have any special articles, but follow the regulations for the management of a company set forth in Table A of the first schedule of the Companies (Consolidation) Act, 1908.

All the documents necessary for the incorporation of a company have to be stamped, and it is necessary to know what the duties are. The memorandum of association and the articles of association must each be stamped as a deed with a ten-shilling stamp, and in addition must each have a fee stamp. That on the articles is five shillings, irrespective of the amount of the capital, but that on the memorandum is on a sliding scale. The minimum is two pounds, and covers the first £2000 of nominal capital. Above £2000 and up to £5000 the fee is one pound per thousand, with five shillings for every thousand above £5000 and up to £100,000, and a shilling for every thousand beyond £100,000 up to £525,000, when the maximum fee of £50 is payable. The certificate setting forth the nominal capital of the company has to pay an *ad valorem* duty of five shillings per cent., so that, if the capital is £100,000, the duty is £250. Every other document requires a five-shilling stamp.

All the documents being in order, the Registrar of Joint Stock Companies grants a certificate of incorporation, and it is the usual custom for this certificate to be framed and hung in the registered offices of the company. With regard to these registered offices, the Act enjoins that "every limited company shall paint or affix, and keep painted or affixed, its name on the outside of every office or place in which its business is carried on, in a conspicuous position, in letters easily legible." In addition the company must have its name engraven in legible characters on its seal, and mentioned in legible characters in all notices, advertisements, and other official publications of the company, and in all bills of exchange, promissory notes, endorsements, cheques, and orders for money or goods purporting to be signed by or on behalf of the company, and in all bills of parcels, invoices, receipts, and letters of credit of the company.

If the company fails to carry out the provision with regard to the name being affixed outside the office, it is liable to a fine not exceeding five pounds for every day during which its name is not painted or affixed in the manner indicated; and if the company's seal or any notice, advertisement, or other official document is issued without its name being mentioned in the manner described, the director, manager, or officer responsible is liable to a fine not exceeding fifty pounds, and is further personally liable to the holder of any bill of exchange, promissory note, cheque, or order for money or goods which are so issued.

The memorandum of association mentions the capital of the company, but there are a number of terms in connection with capital that must be understood. When the memorandum states that the company's capital shall be £100,000, divided into twenty thousand ordinary shares of five pounds each, this is called the *authorised capital*. It is also known as the *registered capital* and the *nominal capital*. These three terms mean the same thing. While thus insuring the legal right to raise so much capital, the directors may decide to issue for subscription by the public only a part of this amount—say, £50,000. This is called the *issued* capital. The rest of the nominal capital is called the *unissued capital*. But the public may not be inclined to subscribe the whole of the capital issued. Only £30,000, say, may come in. This is called the *subscribed capital*. Usually, the directors of a company do not ask for the whole value of each share to be paid up at once by those subscribing. A certain proportion has to be sent on application, some more on allotment, and perhaps a further sum

three months later. The total amount of the subscribed capital thus called for by the directors is known as the *called-up capital*, and the total amount of subscribed capital remaining to be called is the *uncalled capital*. The actual amount received to date from shareholders is the *paid-up capital*, and the amount remaining for the carrying on of business by the company after all expenses connected with the forming of the company, the purchase of its assets, and so on, are paid, is known as the *working capital*.

According to the Companies Act of 1908, "No allotment shall be made of any share capital of a company offered to the public for subscription unless the following conditions have been complied with, namely: (a) the amount (if any) fixed by the memorandum or articles and named in the prospectus as the minimum subscription upon which the directors may proceed to allotment; or (b) if no amount is so fixed and named, then the whole amount of the share capital so offered for subscription has been subscribed and the sum payable on application for the amount so fixed and named, or for the whole amount offered for subscription has been paid to and received by the company." The amount so fixed and named has to be reckoned exclusively of any amount payable otherwise than in cash. The amount payable on application on each share shall not be less than 5 per cent. of the nominal amount of the share. It is further specified that "If the conditions aforesaid have not been complied with on the expiration of forty days after the first issue of the prospectus, all money received from applicants for shares shall be forthwith repaid to them without interest; and if any such money is not so repaid within forty-eight days after the issue of the prospectus, the directors of the company shall be jointly and severally liable to repay the money with interest at the rate of five per centum per annum from the expiration of the forty-eighth day, provided that a director shall not be liable if he proves that the loss of the money was not due to any misconduct or negligence on his part."

Whoever sets the machinery going for the formation of a company is called a "promoter," and promoting is now a recognised profession with specified responsibilities. A promoter is an expert in all the matters preliminary to the registration of a joint-stock company, and he has an intimate knowledge of the financial world and the investing public. Any personal gain he may obtain in promoting a company must now be fully divulged to independent representatives of the company; and if the public are invited to subscribe to the share capital, then they, too, must be informed of any gain the promoter is obtaining for his work of establishing the company.

When the capital of a company is required from the public, a prospectus is issued, and this is described in the Companies Act (1908) as "Any prospectus, notice, circular, advertisement, or other invitation, offering to the public for subscription or purchase any shares or debentures of a company." The prospectus is issued by the authority of the directors, all of whom must sign it, and a dated copy has to be filed with the Registrar of Joint Stock Companies on or before the day on which it is published. Every prospectus must bear the words "This prospectus has been filed with the Registrar of Joint Stock Companies."

The Act of 1908 is very stringent as to the prospectus being a full disclosure of all the facts that should be known to the public who are being asked to subscribe. A very long section deals with this point, its provisions enumerating the disclosures that must be made to ensure complete openness on the part of all who may profit by the promotion of the company. It should be very carefully studied.

If for any reason a company does not issue a public invitation and prepare a prospectus, it must not, according to the Act, allot any of its shares or debentures unless, before the first allotment of either shares or debentures, there has been filed with the Registrar of Companies a statement in lieu of prospectus, signed by every person who is named therein as a director or a proposed director of the company, or by his agent authorised in writing, in the form and containing the particulars set out in the Second Schedule to the Act. This, however, does not apply to a private company. The statement sets forth in tabulated form most of the facts that are contained in a prospectus.

Seeing how important it is that the prospectus should comply in every point with the Companies Act, and make a telling appeal to the public who are asked to subscribe, it is essential that every prospectus should be prepared by an expert

in company law and business. As can be seen, no material fact of interest to shareholders must be withheld, every statement made must be capable of substantiation, and the whole prospectus should give the impression of being a plain and straightforward record of fact. Upon the attractiveness of the appeal made, and the proposition suggested, depends the raising of the necessary capital, and so the opening part of the prospectus should be drawn up with great care. While not expressing too rosy a view of the future earnings of the company, the possibilities based on some definite data should be made attractive enough to appeal to persons with money to invest; and, to give confidence, as good a board of directors as possible should be formed—substantial business names nowadays proving far more attractive than a board of titled nobodies.

The most appealing story, as set forth in a prospectus, is going to have little effect if it is not printed in an attractive form. Business men and people with money to invest do not, of course, want "frills" in a document inviting them to subscribe, but, at the same time, the greatest care must be taken that the prospectus shall be set up in clear and pleasing type, and in such a way that the salient facts stand out, and catch the eye of the reader at a glance. If a prospectus has not an attractive appearance it is so much waste paper, for it will be thrown away without having been read. The matter should not be left entirely to a printer, even if he does a good deal of business in prospectus setting. General lines must, of course, be followed, but the advice of someone who is an expert in typography should be sought, and any fee that may be paid in getting help of this kind is well expended. The proof will have to be read very carefully, so that no wrong figures may creep in, and every amount should be checked before the final printing.

With every prospectus is sent an application form, which the recipient can fill up with the minimum of trouble when he applies for shares, and this usually has to be sent with a cheque to the company's bankers. It reads something like this: "To the Directors of the Mid-China Mining Company, Limited. Gentlemen, having paid to your bankers the sum of £........ being a deposit of 2s. 6d. per share on application for .... ordinary shares of £1 each of the Mid-China Mining Company, Limited, I hereby request that you will allot me that number of shares, and I agree to accept such shares, or any less number that may be allotted to me, upon the terms of the prospectus of the company, dated July 10th, 1914, and the memorandum and articles of association, and I authorise you to place my name upon the register of shareholders in respect of any shares so allotted to me, and I agree to pay the amount due on allotment and further instalments as and when the same become due." Then follows a place for the signature and address. At the bottom, with a perforated line, so that it can be easily torn off, is a form of banker's receipt, which is filled up by the bank when it receives the applicant's cheque, and posted to him. The receipt usually bears the words: "This receipt, when returned from the bankers, should be preserved by the applicant, to be exchanged, with the receipts for the remaining payments, in due course for a share certificate."

The application usually has to be sent to the company's bankers, but sometimes it has to be sent to the company's registered office direct, and sometimes to their brokers.

The prospectuses, being ready, have now to be issued; that is, in some way brought before the notice of likely investors. In the old days envelopes were addressed from directories, but now there are several addressing agencies who have organised the business on a highly scientific basis. They have carefully compiled lists of selected names, and can usually provide a big list of persons likely to be interested in any particular financial proposition. This has, of course, simplified the issuing of a prospectus, and saved a great deal of waste in printing and postage, for under the old method of using directories promiscuously the wastage was enormous. These lists include special selections of persons interested in mining companies, in industrial concerns, in railway undertakings, and so on.

These agencies address the envelopes, and will insert the prospectus with the application form, and any other necessary document, and post the whole batch. Prospectuses should always be sent out in envelopes of a fairly good quality, and should be stamped with penny stamps rather than franked in bulk by the Post Office. The ordinary stamp method gives individuality to each envelope.

Besides sending out some thousands of prospectuses to likely investors, an abridged prospectus is usually printed in the advertisement columns of the best daily newspapers and the financial journals. This advertising should be placed in the hands of some reputable firm of advertising agents who make a speciality of prospectus work. It will be just as cheaply and far better done than if the promoter tries himself to deal with the different papers individually. Many points have to be considered carefully, such as the position in the newspaper where the advertisement is to appear, the day on which it is to come out, and so on. It would be a mistake to advertise a prospectus on a day when many other prospectuses, all appealing for the investors' money, are also advertised. If, too, the papers were full of some exciting news, such, for instance, as the loss of a big liner, attention would be diverted from the advertised prospectus, and it might very largely miss fire.

In a prospectus the time during which the lists will be kept open is stated, usually two or three days, and during that time applications for shares will probably be coming in if the company is an attractive one. If different kinds of shares—ordinary, preference, and so on—are offered at the same time, it is a good plan to have the application forms for the different kinds of shares different colours: this prevents any mixing up of the applications in the company's office. When the time for closing the lists has expired, the application forms are collected from the bank and numbered consecutively. Particulars of these applications are then tabulated on sheets, the names being written alphabetically. The sheets are ruled into columns for the number of the application, the date of application, the applicant's name, his address, his occupation, the number of shares applied for, the amount paid on application, the date of allotment, the number of shares allotted, their numbers (from and to so-and-so), the number of the allotment letter, the total amount due on allotment, the folio in the share ledger, and the number of the share certificate. When all the applications have been thus analysed and entered on the sheets, the secretary totals up the number of shares applied for, to see if the minimum on which the company may go to allotment has been subscribed. If it has not, then the directors may not go to allotment, and they must return all the amounts received to the applicants. If more than the issue capital is subscribed—that is, if there are applications for more shares than are available—then the applications are gone through carefully, and to some applicants are sent what are known as *letters of regret*—that is, formal notes saying that the directors regret they are unable to allot the shares applied for, and they therefore enclose a cheque for the amount paid on application. The applications thus eliminated are usually those from persons whom the directors consider least desirable—members of rival firms, and so on. Even after throwing out these, there may still not be enough shares to meet all the applications. In such case the directors decide how many shall be allotted to each applicant; and if fewer are allotted than were applied for, the balance of the money sent on application is usually held to go towards the money payable on allotment.

Preliminaries settled, the directors go to allotment. They hold a meeting of the board, when the secretary will report that, as a result of issuing the prospectus, applications for so many shares have been received, details of which are given on the sheets laid before the meeting. The directors then resolve that so many shares be allotted, the resolution being worded something like this: "That 50,000 ordinary share of £1 each be and are hereby allotted to the persons whose names, addresses, and descriptions are respectively set forth in the allotment sheets now before the board, in accordance with the number of shares specified in the allotment columns therein, and that the secretary be and is hereby instructed to issue the necessary allotment letters and letters of regret forthwith, and to return the application money whereever necessary."

The letters of allotment are now sent to applicants to whom shares have been allotted. A printed form is used, the details being filled in for each particular letter, and it is very important that there shall be no error in these or in the letters of regret. Every letter should be checked by someone other than the person who made it out. The wording will be something like this: "The Mid-China Mining Company, Limited. Dear Sir,—I am instructed by the directors of the Mid-China

Mining Company to inform you that in response to your application they have allotted you one hundred ordinary shares of £1 each in the company. The amount now due from you in respect of these shares is £25, being 5s. per share payable upon allotment. Will you kindly pay this amount to the company's bankers, The Far Eastern Bank, 25, Cornhill Place, London, E.C., on or before August 10th, 1914 ?—I am, etc."

The letters of allotment should be posted as soon as possible, and a carefully certified note kept of the date and place of posting, as, until this has been done, an applicant may withdraw his application. Once, however, the letters of allotment are posted, there can be no withdrawal on the part of either the applicant or the company. Letters of allotment for amounts of five pounds and upwards must be stamped with a sixpenny stamp; those for less than five pounds, with a penny stamp. Allotment has to be made within forty days after the first issue of the company's prospectus, and if this is not done all moneys received must be returned in full to the applicants.

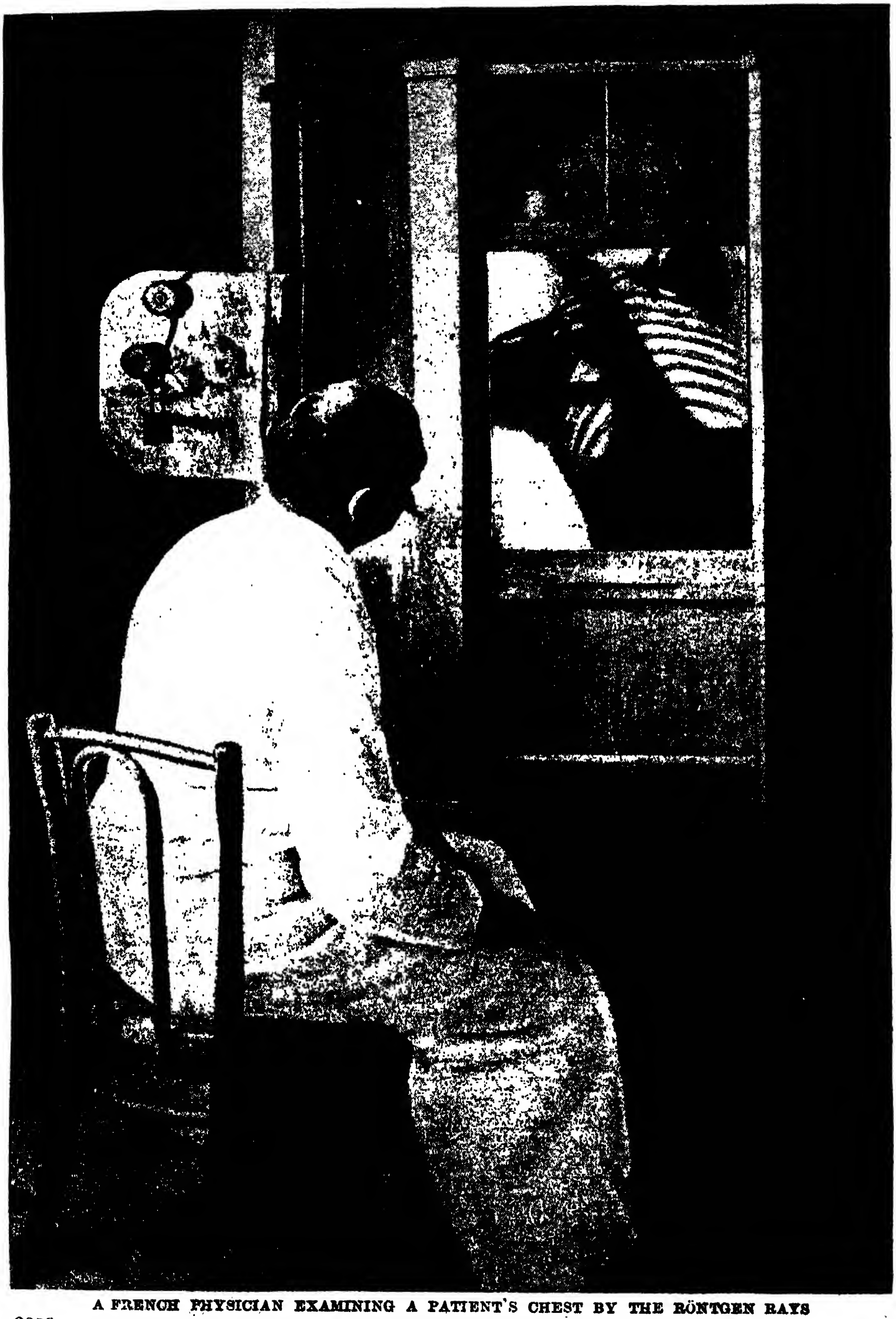
An allotment made to an applicant in contravention of the provisions laid down by the Companies (Consolidation) Act, 1908, is voidable at the instance of the applicant within one month after the holding of the statutory meeting of the company, and not later, and is so voidable notwithstanding that the company is in course of being wound up. Any director who knowingly contravenes or permits or authorises the contraventions of any of the provisions with respect to allotment is liable to compensate the company and the allottee respectively for any loss or damage they may have sustained thereby.

As the allotments are made and the letters of allotment sent out, the names of the shareholders have to be entered in the share register. This is a book specially ruled with columns for the following items in consecutive order: First come "Shares acquired" as follows: The date of allotment or of registration of transfer; the number of the transfer deed or allotment letter, folio, number of shares acquired, distinctive numbers of shares, amount paid up, number of the certificate. Then comes "Shares disposed of" as follows: Date transfer registered, number of transfer deed, folio, number of shares transferred, distinctive numbers, amount paid on shares. In the succeeding columns are particulars of the amounts paid on the shares and the dates of the different calls. Each shareholder has a double page in the register, with his name, address, and description at the top. Entries are also made in the share ledger, and then the share certificates must be made out and sent to the shareholders. A single certificate may include all the shares of one class held by a member. The certificate is usually more or less ornate, records the fact that So-and-so is the registered holder of so many ordinary or preference shares of so much each in such and such a company, the shares being numbered from, say, 101 to 201 consecutively. In the book the certificates are in three parts, with perforations to separate them. There is the counterfoil that remains in the book, the certificate itself, and the receipt or form of acknowledgement which the shareholder sends back to the secretary. According to the Companies Act, 1908, "a certificate under the common seal of the company and specifying any shares or stocks held by any member shall be prima facie evidence of the title of the member to the shares or stock." The certificates for the different classes of shares are usually printed in different colours.

Within one month after the allotment of the shares, a return of the allotments, stating the numbers and nominal amounts of the shares comprised in the allotment, the names, addresses, and descriptions of the allottees, and the amount, if any, paid or due and payable on each share, must be filed with the Registrar of Companies. Where the shares are allotted as fully or partly paid up otherwise than in cash, a contract in writing constituting the title of the allottee to the allotment, together with any contract of sale, or for services or other consideration in respect of which that allotment was made, such contracts being stamped, and a return stating the number and nominal amount of shares so allotted, the extent to which they are to be treated as paid up, and the consideration for which they have been allotted, must be filed.

Sometimes when a company is being formed, or when new capital is being raised, certain persons guarantee to obtain subscribers for the capital, and for this they receive a commission on the nominal amount of the shares they guarantee. This is called underwriting, and the guarantor is an underwriter. CHARLES RAY

SEEING THE BONES OF A LIVING MAN



A FRENCH PHYSICIAN EXAMINING A PATIENT'S CHEST BY THE RÖNTGEN RAYS

The Discovery of the Röntgen Rays and their Use in Surgery. Theories Concerning their Effects. Laws of Radiation.

THE WONDERFUL RÖNTGEN RAYS

WE are already quite familiar with the fact that the radiations called light have variously been conceived as consisting of undulations or vibrations in the ether, or of minute material particles moving through space at high speeds. We know, also, that the latter or Newtonian view is now disproved; but it is extremely important for us to recognise that the word *radiation* is now used in physical science to cover two very different things—first, various wave motions in the ether; and, second, various corpuscular motions which are not light but which have a very striking resemblance to Newton's theory of light. We may quote from Mr. Soddy, one of the most distinguished of the workers in this field, a definition of the use of the word radiation in its wide modern sense. He says " the term *radiation* is properly applied to indicate an influence transmitted *radially* from its source to its surroundings, and capable of traversing vacuous space without occupying in its transmission a period of time great enough to be sensible under ordinary circumstances." The reader will not be misled by Mr. Soddy's use of the word *vacuous*. It means vacuous as regards ponderable matter, but certainly not vacuous as regards the ether.

The Work of Sir William Crookes. It was Sir William Crookes who first recognised the existence of radiations more or less corresponding to the type imagined by Newton. In order to understand his discovery, we must briefly note the elementary facts of a vacuum tube. An electric current can be made, under favourable conditions, to spark across a gap of air, but a very great measure of electric force is necessary to maintain any appreciable discharge across even a very small interval of air at the atmospheric pressure, while a still greater force is needed to start the process. The passage of the spark is made very much easier by lowering the atmospheric pressure. This can be easily shown by sealing platinum wires, which act as electrodes, or conveyers of electricity, into small glass tubes, most of the air of which has been removed. But at this point we cannot do better than quote from another distinguished worker in this field, Mr. Whetham.

"For many years these vacuum tubes, as they are called, were the electrical playthings of the laboratory and popular lecture-room. Recent discoveries have raised them from the position of scientific toys to the rank of pieces of apparatus whereby have been made some of the greatest discoveries in physical knowledge that the present generation has seen. Through such a tube, in which the pressure of the air is only a small part of an atmosphere, a discharge may readily be passed by the aid of a voltaic battery and an induction coil, or by the use of an influence electric machine. As in liquid conductors, the electrode by which the current enters is called the *anode*, and that by which it leaves, the *cathode*. Starting from the cathode, we first see a bright glow covering its surface, then a space, succeeded by a second dark space, beyond which is a luminous column reaching to the anode. Within certain limits of pressure and strength of current this positive column, as it has been called, shows fluctuating striations. If the length of the tube be increased, it is this positive column alone which increases with it; the two dark spaces and the negative glow vary very little with the length of the tube."

The Cathode Rays. Sir William Crookes proceeded to study the consequences of making the vacuum in such a tube extremely high, and he discovered, as some of his predecessors had suspected, that certain rays are produced, which we now know as *cathode* rays. The greater the exhaustion of the tube the greater becomes the size of the dark space or "Crookes' dark space," around the cathode. At last this fills the whole tube, and the glass opposite the cathode begins to display a green phosphorescent appearance. Furthermore, if a mica screen be interposed between the phosphorescent glass and the cathode, a shadow which is notable for its sharp definition appears, demonstrating that some kind of rays, able to produce phosphorescence in glass, are being thrown out from the cathode in straight lines. The properties of these cathode rays are extremely remarkable. They produce heat in any body which obstructs them, and they possess energy, since they will drive round a little windmill placed in their way They will actually produce so much heat as under favourable conditions will suffice for melting a piece of platinum wire or charring a diamond.

The Cathode Rays and Magnetism. Most interesting of all are the relations of these cathode rays to a magnet, *which deflects them.* The deflection is that which would be expected in the case of negatively-electrified particles travelling along the path of these rays. Says Sir Joseph J. Thomson, summing up the researches which have since been made on this point: "Thus the cathode rays carry a charge of negative electricity, they are deflected by an electric field as if they were negatively electrified, and are acted on by a magnetic force in just the way this force would act on a negatively-electrified body moving along the path of the rays. There is, therefore, every reason for believing that they are charges of negative electricity in rapid motion, and by measuring the deflection produced by magnetic and electric fields we can determine the velocity with which these particles move and the ratio of the mass of the particle to the charge carried by it."

It is interesting to note that Sir William Crookes gave a correct explanation of the cathode rays from the first. He said that they were "streams of negatively electrified particles projected normally from the cathode with great velocity."

Röntgen's Remarkable Discovery. Professor Röntgen was enabled to observe the invisible rays that go by his name, in virtue of the fact that he happened to be keeping some photographic plates, well covered, in the neighbourhood of a very highly exhausted vacuum tube. He then found that these plates looked as if they had been exposed to light. This was well worth looking into. He found that if he used a screen covered with some phosphorescent substance, it began to glow brilliantly under the influence of *something* that emerged from the tube. Further, he found that certain substances obstructed this something, while others did not. "He found that if a thick piece of metal were placed between the bulb and the phosphorescent screen a sharp shadow of the metal was cast upon the screen, but that other substances, such as wood and thin pieces of aluminium, cast but slight shadows, showing that the agent which produced the phosphorescence could traverse with considerable freedom bodies which are opaque to ordinary light. He found that as a general rule the greater the density of the substance, the greater its opacity to this agent. Thus, while the effect produced by the phosphorescence could pass through the flesh, it was stopped by the bones of the hand, so that if a hand were held between the discharge tube and the phosphorescent screen the outline of the bones was distinctly visible as a shadow cast on the screen; or if a purse containing coins were placed between the tube and the screen, the purse itself threw but little shadow, while the coins cast a dark one."

Character of the X-Rays. Professor Röntgen was worthy of his good fortune, and made the most of it. He showed that the rays move in straight lines, and that on passing from one medium to another they undergo no refraction. Unlike the cathode rays, they are unaffected by a magnet. Sir J. J. Thomson says that he has "sent the rays through a magnetic field of about 8000 lines of force per square centimetre for a distance of about a centimetre without producing any appreciable defect."

In certain notable respects the rays resemble light. Like light, they are propagated in straight lines, they feebly stimulate the retina, they affect the photographic plate, they are not deflected by electric or magnetic influence, and so on. Furthermore, the absence of any refraction does not exclude the possibility of their being really identical with light. Sir Joseph Thomson points out that, according to any theory of refraction—which we must conceive as dependent upon the ratio between the period of vibration of the refracting body and the period of the vibrations of light—"there would be no refraction for light of very small period, and this would also be true if, instead of regular periodic undulations, we have a pulse of electromagnetic disturbance, provided the time taken by light to travel over the thickness of the pulse be small compared with the periods of vibration of the molecules of the refracting substance."

At a comparatively early stage in the inquiry it was found that the Röntgen rays vary somewhat according to the conditions under which they are produced. This is an important matter theoretically, since it suggests, for instance, that there may be a whole series of "notes" of Röntgen rays, corresponding to the notes or colours of visible light. Physicians and surgeons also have come to recognise the extreme importance of distinguishing the various kinds of Röntgen rays, since one kind may have a curative effect which is entirely absent from the others. If the vacuum tube has not been exhausted to any very great degree—the gaseous pressure within it, therefore, remaining pretty high, with the consequence that the potential difference between its electrodes is small and the velocity of the corpuscles between them correspondingly low—the Röntgen rays produced outside the tube are called *soft* rays, and have the character that they are very readily absorbed.

Penetrating Power of the Rays. Very different, indeed, is the penetrating power of the rays produced in a tube which is very highly exhausted. In such a tube, where the potential difference between the two electrodes is high, the cathode rays travel with much greater speed, and the variety of the Röntgen rays they then produce are called *hard* rays. Says Sir J. J. Thomson: "With a highly exhausted tube and a large induction coil it is possible to get appreciable effects from rays which have passed through sheets of iron or brass several millimetres thick. The penetrating power of the rays thus varies with the pressure in the tube; as the pressure in the tube gradually diminishes, when the discharge is kept running through the tube, the type of discharge proceeding from the tube is continually changing. Not only do different bulbs emit different kinds of rays, but the same bulb may emit, at the same time, rays of different kinds. The property by which it is most convenient to identify a ray is the absorption it suffers when it passes through a certain thickness of aluminium and tinfoil." But, nevertheless, experiments made on this point show that the rays vary among themselves even more than was thought; and, as has before been stated, this question of the difference between various kinds of Röntgen rays is not only one of great physical interest, but may also frequently be a matter of life and death.

Nature of the Röntgen Rays. For years it could not be said that the real nature of the Röntgen rays was *proved*, though in all probability they were neither material particles nor longitudinal waves in the ether, as the discoverer himself had suggested, but consisted of transverse ethereal disturbances. But if they were transverse they ought to be polarisable, and until quite lately all attempts to polarise them had failed. The use of tourmaline plates gave

no evidence of polarisation. Subsequently, however, another method was employed, in describing which we may quote from Mr. Strutt, who is the son and heir of Lord Rayleigh, a former President of the Royal Society, and affords a conspicuous instance of inherited scientific genius. He has made very important contributions to various aspects of the subject which we are now discussing.

"The rays," says Mr. Strutt, "are allowed to fall on some light substance, such as paper or carbon. Under these circumstances the paper or carbon becomes itself a source of rays—secondary rays, as they are called. The amount of secondary radiation in any fixed sideways direction is found to vary, as the vacuum bulb giving out the original rays is made to turn round in such a way as to rotate the beam of rays on itself, without changing its direction. This proves that the beam has a one-sided character, and establishes most satisfactorily that the vibrations must be in a transverse direction; for if the vibrations were longitudinal it is impossible to conceive how turning the beam round could make any difference. Later and more elaborate experiments have shown that this one-sidedness is much more marked in the secondary rays themselves than in the original ones from the bulb."

APPARATUS FOR MAKING AN X-RAY PHOTOGRAPH

This must obviously be regarded as conclusively proving that the Röntgen rays are essentially identical with light. If we could show finally that the rays have the same speed as light we might regard our proof of their nature as complete. It has been attempted "to compare the speed of the rays with the speed of electric waves travelling along a wire, which is known to be the same as that of light," and these experiments seem to show that, as might be expected, the velocity of the Röntgen rays is identical with that of light.

Uses of the Röntgen Rays. Let us now turn from the purely physical aspect of this study to the question of utility, which, as a matter of fact, has advanced very much more rapidly than the purely scientific question. No sooner had Professor Röntgen demonstrated the fact that he could see his own bones, or rather their shadows, projected by the rays than the surgeons turned the fact to account. Plainly, this property would be very much to the point if it were applied to broken bones, the position of which is often very difficult but always very important to ascertain. Nowadays a thoroughly up-to-date surgeon with a perfect equipment and plenty of time not only uses the Röntgen rays in every case of fracture, but, after the fracture has been set, and the bandages and splints and all have been put on, takes another photograph, so as to make quite sure that the fragments of the bone are lying in perfect position.

The Enormous Gain to Humanity. The surgeon acts similarly in the case of dislocations, in the case of bullets, and needles. On this mere point of finding needles the reader can have little idea how many women the discovery of the Röntgen rays has benefited. Furthermore, it is quite easily possible to see the movements of the heart by means of the Röntgen rays, and this has enabled doctors to confirm the theories formerly held as to the causation of the various sounds produced by the normal and the abnormal heart. Many cases of the disease known as aneurism can also be readily detected by the size of the shadow which the diseased artery throws upon the screen. Furthermore, the early signs of consumption or tuberculosis of the lungs can be detected by the increased opacity which this disease causes to these rays, and some observers are of opinion that the disease can be thus diagnosed sooner than by any other means. The radiographic observation of consumptive lungs has also been employed in order to study the effects of special modes of treatment. Again, there is a large number of different kinds of stone occurring in the body, the presence of which can be detected by the shadow which they cast under these rays—a means of diagnosis which is now of the utmost value in surgery.

The Röntgen Rays and Living Matter. It is a curious circumstance that, so far as can be judged, the X-rays have no deleterious action upon microbes. This is curious, because, as we shall see, they are of very great value indeed in the treatment of various diseases of microbic origin. When the Röntgen rays are allowed to act upon the skin, they cause a number of remarkable changes in time. They very often destroy entirely the roots of the hair,

though hitherto it has not been possible to control the production and character of the rays in sufficient degree to justify their use as a substitute for the razor in the case of persons who spend a considerable part of their lives in keeping down a beard; and the reader is warned against the application of the rays for depilatory purposes. The skin itself is also apt to undergo various changes, which may amount either to severe inflammation or even to actual destruction. It is the lamentable fact, also, that the ulcers produced by these rays sometimes become cancerous. Doctors and their assistants, working in the Röntgen ray departments of hospitals, are now learning that it is necessary to protect themselves by means of leaden gloves or shields. The most opaque substances to the Röntgen rays are platinum, mercury, bismuth, lead, and silver.

Diseases Cured by Röntgen Rays. The public are already familiar with the use of the Röntgen rays in diagnosis, but in quite recent times they have been employed as a means of treatment, and in many cases their use has been followed by the most astonishing, not to say unexpected, success. Like ultra-violet light, the Röntgen rays are perfectly effective in curing lupus, but their penetrative power is far greater. In the therapeutic use of ultra-violet light, great importance is attached to the exclusion of as much blood as possible from the area of the skin to be acted upon, for even the thinnest film of blood absorbs these rays. Very different, however, are the Röntgen rays, which will pass right through the body, and thus their range of employment as therapeutic agents is very much greater than that of ultra-violet light. The Röntgen rays will cure deeply situated cases of lupus against which the Finsen treatment seems to be entirely powerless.

Besides this disease, a dozen other diseases of the skin might be named, including notably ringworm and its allies, which are curable, and are now constantly treated, by the Röntgen rays. Much more important is the conquest by this means of one variety of cancer—that known as *rodent ulcer*. It is true that this is by far the least malignant variety of cancer, and the reason why it alone is susceptible to the action of the Röntgen rays is doubtless that it is also the most superficial variety. But rodent ulcer is a common disease, and no words can say how magnificent is the gain involved in the displacement of the knife by these rays in the treatment of this once terrible disease.

Cures by Röntgen Rays. These facts raise questions of the very greatest scientific interest, and more especially when we realise that the rays apparently have no antiseptic action in the ordinary sense. The cures they effect seem to be due to their stimulation of the tissues of the body, and the question we must ask ourselves, without any possibility as yet of answering it, is: How do these electromagnetic pulses so affect living matter as to give rise to these consequences? Science will have advanced much further before it is possible to explain these facts in physico-chemical terms.

The rapid advance of the physics of the Röntgen rays has been of great value, of course, as regards their application in what used to be called physic. Notably, it is now being found that when rays of the right kind are employed in sufficient abundance their therapeutic action is very far from being confined to the surface of the body. On the contrary, there are various diseases of the internal organs, most of them responsive to no other kind of treatment, in which great gain results to the patient from the employment of the Röntgen rays. It is nothing short of amazing to contemplate the revolution in many branches both of surgery and of medicine which has been effected in a few short years as a direct consequence of Professor Röntgen's first observation.

All-important for use is the recently gained power of exactly controlling the nature of the particular rays employed. It was not enough to have a radiation mostly hard but including many soft rays, or vice versâ, for in either case the minority of the rays employed were doing, or liable to do, that which they should not. But when the clinician can be provided with radiation that is all, or practically all, hard or soft, great possibilities are opened. Internal organs, and above all the reproductive glands, are strikingly affected by the hard rays, losing their normal powers of forming the germ-cells. It is evidently necessary that such a fact should be known, now that the hard rays are so largely employed. On the other hand, the hard rays have an effect, much to be desired, upon malignant cells, in the same direction. The explanation of the parallel action probably is that young and rapidly growing cells are chiefly susceptible to the rays—and both the germinal and malignant tissues answer to this description.

But it is practically impossible to bring the hard rays, as at present produced, to bear upon deep-seated malignant growths. Hence the tragic interest which attaches to the apparently well-vouched-for discovery of a new type of vacuum tube, which produces rays of a hardness or penetrative power hitherto unprecedented. This Coolidge tube, as it is called after its inventor, has yet to be studied on this side of the Atlantic, but hopes are entertained that it may more than rival the best doings of radium itself in the treatment of malignant growths.

The Theory of Radiation. We have now completed our discussion of many various kinds of radiation. We have said all that there is time to say of the rays of ordinary light, the ultra-violet rays, the infra-red rays of radiant heat, and the Röntgen rays. The proposition has been submitted that, widely though these differ from one another in respect of their physical properties, and still more widely in respect of their influence upon our senses, yet they are one and all to be regarded, together with many other radiations known and unknown, as fundamentally identical.

For our present purposes, then, we must dismiss the differences between these various kinds of rays, and must consider the extremely

difficult subject of radiation in general, recognising that by this term we include radiations visible and invisible.

Radiation and Temperature. This is one of the most complex subjects in the whole of physics, and we can present it merely in outline. More important than any of its details is the recognition by the student that there is, or may be, a general theory of radiation. Perhaps the first fact worthy of being insisted upon is the extreme intimacy of the relation between radiation and temperature. This is of the utmost importance in respect of theory, and of equal importance because of the remarkable information which the application of this principle affords us when we turn to the study of the stars. Let us recall for a moment what we have learnt regarding heat. We have seen that heat may be transferred by conduction, by convection, or by radiation, but now we may consider more critically this last process, which we shall find to be fundamentally different from the other two. We know that a radiant body in consequence of its radiation cools. We know also that the bodies which absorb the radiation are heated, but are we entitled to apply the term *heat* to that which passes between the radiating and the absorbing bodies? The nature of the problem is usually obscured by the language we employ. We describe what passes as *radiant heat.* But the critical reader will have already noticed that there is a fundamental distinction between this radiant heat which, according to our latest studies, is none other than an electromagnetic phenomenon of the ether, and the ordinary heat, which consists, as we have said, of a vibration of certain material molecules.

We may use the words of the late Professer Tait in proof that radiant heat is not really heat at all, though it may be in some way caused by heat and in some way cause heat. "When a piece of clear ice is cut into the form of a large burning-glass, it can be employed to inflame timber by concentrating the sun's rays, and the lens does the work nearly as rapidly as if it had been made of glass. It is certainly not what we ordinarily call heat which can be transmitted under conditions like these. Radiation is undoubtedly a transference of energy, which was in the form commonly called heat in the radiating body, and becomes heat in a body which absorbs it; but it is transformed, as it leaves the first body, and retransformed when it is absorbed by the second."

Visible and Invisible Light. The reader will understand that the term "radiating" in the above quotation includes all luminous bodies. We are speaking now not merely of radiant heat, but of light as well. This we shall see by another quotation showing the absolute continuity between the visible and the invisible. "The more intensely a cannon-ball is heated, the more luminous does it become, and also the more nearly white is the light which it gives out. So well is this known that in almost all forms of civilised speech there are terms corresponding to our 'red-hot,' 'white-hot,' etc. As another instance, suppose a powerful electric current is made to pass through a stout iron wire. The wire becomes gradually hotter, up to a certain point, at which the loss by radiation and convection just balances the gain of heat by electric resistance. And as it becomes hotter the amount of its radiation increases, till at a definite temperature it becomes just visible in the dark by red rays of low refrangibility. As it becomes still hotter, the whole radiation increases; the red rays formerly given off become more luminous, and are joined by others of higher refrangibility. This process goes on, the whole amount of radiation still increasing, each kind of visible light becoming more intense, and new rays of light of higher refrangibility coming in, until the whole becomes white—that is, gives off all the more efficient kinds of visible light in much the same relative proportion as that in which they exist in sunlight. When the circuit is broken, exactly the same phenomena occur in the reverse order, the various kinds of light disappearing later as their refrangibility is less. But the radiation continues, growing weaker every instant, even after the whole is dark."

This illustration affords one more proof of the continuity between the visible and the invisible, but it also constitutes an illustration of the proposition that there is a definite relation between temperature and radiation. If we translate what happens into the best symbols that we know, we must imagine that as the molecules of the wire become hotter and the character of their vibrations alters, so they give rise to ethereal waves of shorter and shorter wave-lengths and greater and greater frequency.

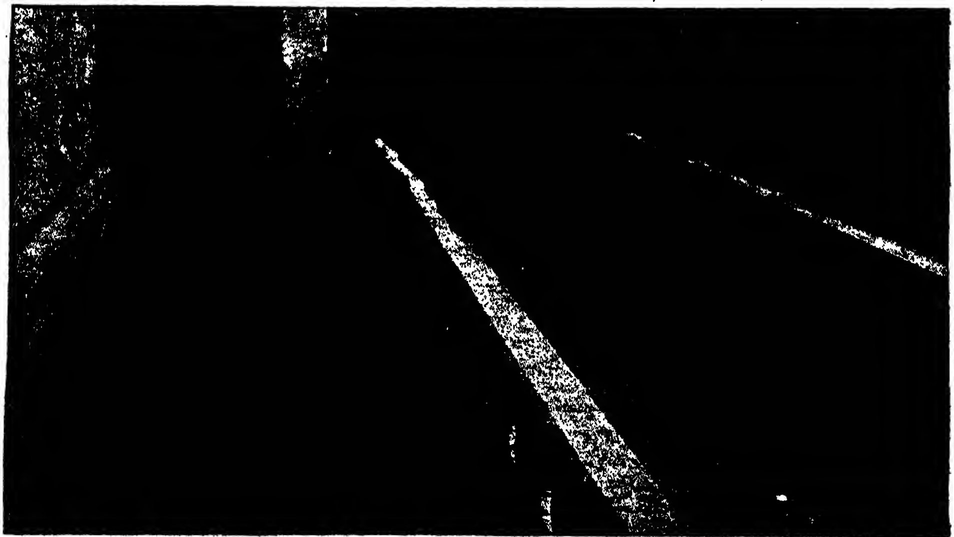
The Laws of Radiation. The whole of radiation, then, is one phenomenon. Let us now consider what general propositions can be advanced beside that of the relation between temperature and radiation. Nearly half a century ago Balfour Stewart showed "the absolute uniformity, qualitative as well as quantitative, of the radiation at all points and in all directions within an enclosure impervious to heat when thermal equilibrium has once been arrived at." He showed, by many experiments and observations, that radiation and absorption rigorously compensate each other, not merely in quantity but in quality also, so that a body which is specially absorptive of one particular ray is in the same proportion specially radiative of the same ray, if its temperature be the same in both cases. Stewart's final statement was that "at any temperature a body's radiation is exactly the same, both as to quality and quantity, as that of its absorption from the radiation of a black body at the same temperature."

The last proposition shows that Stewart worked first at radiant heat, but his propositions were true alike of light. In short, they are true of radiation in general. Balfour Stewart's work was, indeed, a confirmation and extension of the very important idea first enunciated by Prévost in 1791, and called by him the *Law of Exchanges.*

C. W. SALEEBY

MIXING MORTAR WITH LARRY FOR BRICKWORK AND FILLING INTO HOD

FORMING HOLLOW WALLS—SHOWING THE USE OF STRETCHER BOND, TOOTHING, AND DAMP COURSE



SLEEPER WALLS WITH PLATES FOR JOISTS, AND HONEYCOMB BRICKWORK FOR VENTILATION

Arches. Centering for Arches and Vaults. Fireplaces.
Chimney Flues and Stacks. Smoky Chimneys and Remedies.

BRICKWORK CONSTRUCTION

Racking Back. It is desirable that as far as possible all the walls of a building should proceed uniformly, so that at no time may there be any great difference in level between the top of any one wall and another. This cannot always be strictly followed, and where a change of level must occur between one part and another it is best to form this by *racking back* rather than by toothing. Racking back consists in setting back each course at the end of the higher wall a quarter brick beyond the course below [84, page 2724]. There is less liability of a settlement occurring in this case than when toothing is employed.

Temporary openings may be formed in brick walls for the passage to and fro of materials and workmen, or for similar purposes, by toothing the sides and forming the top with oversailing courses; such openings are often protected from damage by short boards fixed against the head.

Brick Arches. Where permanent openings occur in brick walls, they are usually covered by arches also formed of brick. In external walls, for the sake of appearance, no bearer or lintol of wood or iron is, as a rule, admissible; but on the inner part of the wall where the opening is often covered by joinery or plaster, the opening is covered by a horizontal beam termed a *lintol*, either of wood or concrete, and the arch is constructed above the lintol. Such arches, which are termed *relieving* or *discharging arches*, are, as a rule, segmental in form, and the skewbacks should be formed at the extreme end of the lintol; upon them a core is constructed in brickwork and mortar shaped so as to form a permanent centre to the arch which is built up upon it [97]. With concrete lintols, the upper surface is usually cast segmental in form, to receive the bricks of the arch directly.

Centering for Arches. Turning Pieces. Where arches have to be constructed over voids, without lintols, a temporary provision must be made to support them until the mortar is set. In the case of an arch above the reveals of a window, which, as a rule, is only half a brick thick on the soffit, if the rise be small enough to allow of a support being cut out of a single plank or board, this is usually done; a board 3 in. thick is used and the upper side is cut to the curve of the arch to be struck, and the under side is left horizontal; it is fixed upon supports nailed to the jambs of the opening, and is termed a *turning piece* [98]. The arch is constructed on the back of this, which is left in position till the brickwork is set.

If the soffit of the arch exceed half a brick in width, a single turning piece will not suffice, and a centre is formed; two boards are cut to the required shape from planks 1 in. to $1\frac{1}{2}$ in. thick, placed at such a distance apart as corresponds to the width of the soffit, and secured to cross-pieces nailed below at each end; the upper surfaces have a series of wooden strips laid across and nailed to each. These strips are termed *laggings* [99].

For gauged work, the laggings are laid closely side by side, and the centre which is formed thus is termed *close-lagged;* for other classes of arches they are fixed at short intervals.

Built-up Centres. Where the rise of the arch is so great that the support cannot be cut out of a single board, the two sides must each be built up of two thicknesses of wood, so arranged as to break joint, and nailed or screwed together; the outer edges are cut to the curve of the required arch, and laggings are used as before [102].

In the case of arches of considerable rise and span, each of the side supports may require to be strongly framed and strutted in order to support the load; the form of centre will vary with that of the arch, which may be segmental [99], semicircular [102], pointed [101], or elliptical [100]; but, except in the case of arches of very long span, which sometimes have intermediate support, they should be designed so as to throw the weight of the centre and its load on to the two ends.

For large spans, in which the centres have to support very heavy loads, it will not suffice to rely on either nails or screws for holding the sides of the centre truly in form. The centres, then, instead of being built up in thicknesses, are cut from heavier timbers and are framed together where the timbers are joined; the timbers are disposed so as to form the side into a timber truss, rigid in form, which may be supported at the two ends; curved pieces must be added to the regular timbers forming the truss where necessary to give the form required for the arch.

Supporting Centres. It is only in the case of turning pieces and centres for quite small spans that the method of support already described will suffice. For heavier work, the centres are supported by struts, the lower ends of which rest on some solid support, such as the sill of a window opening or the threshold of a door. If the soffit be wide enough to require it, two struts must be provided on each side, with a cross-piece forming the head, which should come under the cross-piece below the end of the centre. Between these, two folding wedges [99] are inserted, and by their means the level of the centre is adjusted. When the brickwork is considered to be quite set these wedges are loosened, and the centre is dropped slightly, so that it is no longer

in contact with the soffit; this is termed *easing the centre*, and should always take place prior to the final removal, which is termed *striking the centre*. After easing, the brickwork should be examined to see that no settlement or failure occurs before striking takes place.

Centres for Vaults. In the case of vaults, if the form is that of a plain, cylindrical, elliptical, or pointed one, it is practically treated like an arch with a very wide soffit, and in addition to the inner and outer frames, intermediate ones must be used to support the laggings.

If the vault be a groined one, formed by the intersection of two plain vaults, we shall require, in dealing with a square bay, four frames, all similar, for the four main faces; there must be in addition two diagonal frames intersecting at the centre, and marking the lines of intersection of the two vaults. If the vault be a large one intermediate frames may be introduced into each of the four compartments, to assist in supporting the laggings, which are laid on parallel to the axes of the two intersecting vaults, and meet above the diagonal frames.

Centres that have been struck may be re-used for other openings of the same size; they are, however, usually made of rough material, and are, as a rule, broken up when finished with.

Various Kinds of Brick Arches. Brick arches may be divided into (*a*) Common, or Rough arches [**97**], (*b*) Axed arches [**98**], and (*c*) Gauged arches [**99**], according to the treatment of the bricks of which they are formed. Common arches are used for all positions in rough and common work, and in better classes of work they are used for most positions in which the arch is covered by joinery or plaster.

In this form of arch the bricks are used without any cutting; it is usual to form all arches of a depth equal to at least two bricks laid on edge, and the depth is in all cases a multiple of 4½ in. In the case of all arches, except those in which the springing and the centre are at the same level, a *skewback* [**99**] must be formed to receive each end of the arch; this is prepared by cutting the bricks carefully to the necessary inclination, which is found by drawing a line from the centre from which the curve is struck to the point in the jamb from which the arch springs, and producing it.

Building the Arch. When the centre is in position a whole brick is laid on end parallel to the skewback, and forms the commencement of the arch at each side; one such brick occurs for every half-brick in the thickness of the soffit of the arch. Between these end bricks a row of bricks on edge is laid on the core, or wood centre, starting from the two sides and meeting at the centre of the arch. The bricks must be set out so that the mortar joint is fine at the lower edge of the brick and broad at the top to make up the excess of length in the extrados beyond that of the intrados. If the width of the soffit be a half-brick, only bats will have to be used; if it be one brick thick, headers are used; and beyond this thickness headers and bats are used as required so as to bond. Such a row of bricks in an arch, equal in height to a half-brick, is termed a *ring*, and the arch is described as a *two-ring* or *three-ring* arch, and so on, corresponding with a depth of two, three, or more half-bricks. When the first ring is completed as described the second ring is formed above it, but the radiating joints between the bricks will not coincide with those of the first ring, but break joint with them, and so also with subsequent rings.

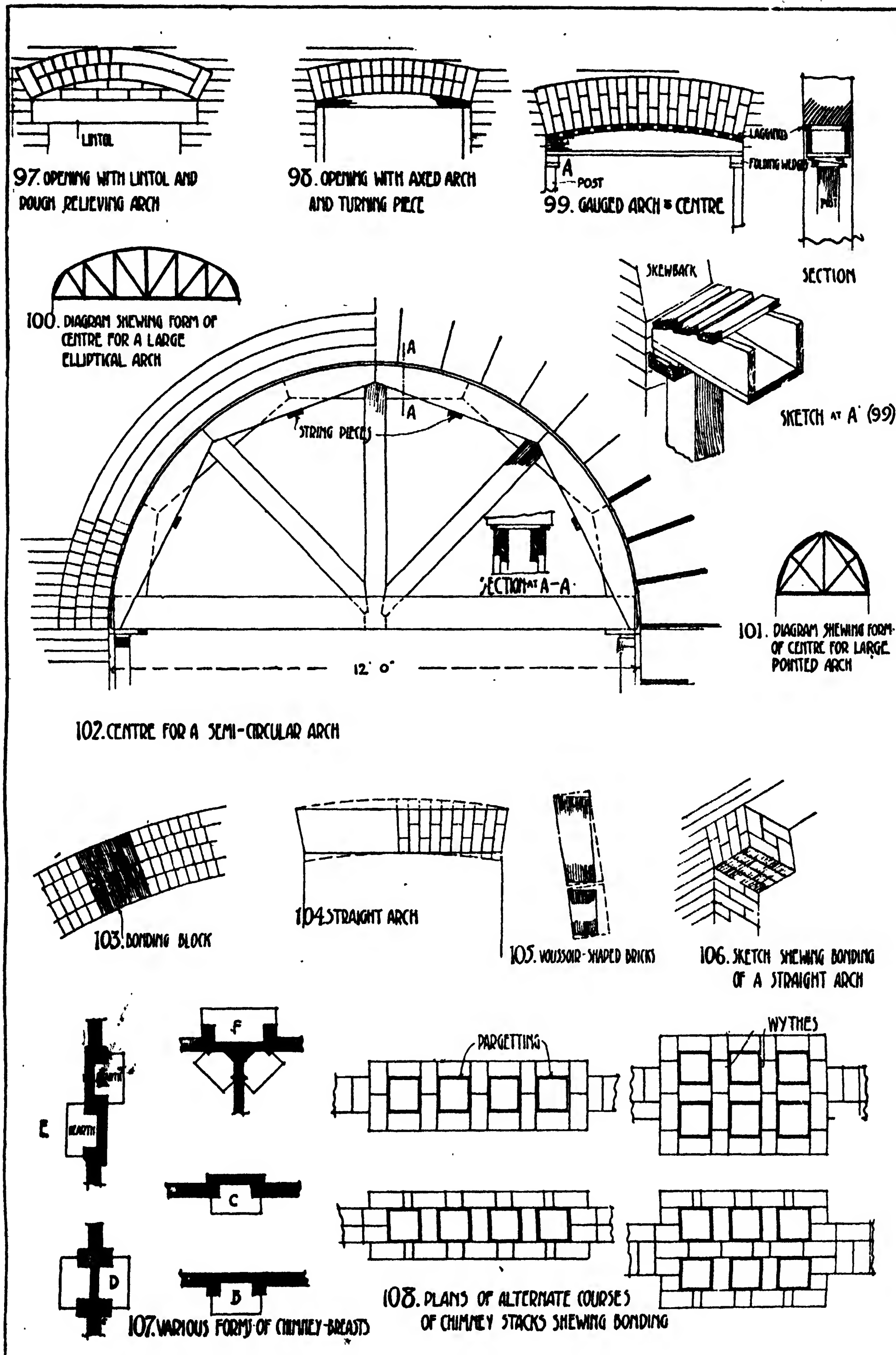
As a rule, in architectural work it is rarely necessary to employ arches exceeding three rings in depth or four at the outside, but where deep arches are required, which only occurs with a wide span, there is sometimes a tendency for the rings to settle separately and to separate from each other. To obviate this, carefully bonded blocks of brick termed *bonding blocks* extending through the full depth of the arch are introduced at intervals in such arches [**103**], or blocks of stone may be substituted. Arches are occasionally constructed of one ring of bricks only in depth, but, as a rule, for any span up to 6 ft. a two-ring arch is employed; from this width up to 16 ft. a three-ring arch, and up to 24 ft. a four-ring arch.

In the case of arches of large span it may be necessary to load temporarily the crown of the centre to prevent it from being distorted by the pressure on the sides. In the case of a brick vault, if of barrel form it is treated like an arch with a wide soffit, but if groined great care must be taken in forming the groins, the bricks for which must be axed or rubbed to the required form. The construction is facilitated by the use of groining ribs, which are in reality independent arches, and these may be first constructed on their own centres and the general surface afterwards filled in on smaller separate centres; this system is usually adopted for stone vaults.

Arches in Axed and Gauged Work. Axed and gauged arches have the bricks prepared as already detailed for these two classes of work, the latter having fine putty joints, and being used for the best class of work, but they may be described together so far as general treatment is concerned.

The essential difference between both of them and a rough arch is that instead of using parallel-sided bricks the bricks are cut or rubbed into a wedge-shaped block termed a *voussoir* [**105**], while the joints are of uniform thickness throughout; and the excess in length of the extrados over that of the intrados is thus formed in the brick and not in the mortar joint [**99**], giving a greatly improved appearance to the work, but adding to its cost. Whatever the depth of the arch, each voussoir extends through the full depth, and is, where necessary, formed of two or more bricks in height, so that a complete bond may be secured; but the width of each voussoir at the extrados cannot exceed the width of a brick, and if the arch be deep the width at the intrados is much reduced.

Any of the ordinary forms of arch described under Rough Arches as capable of construction can be better formed for facing work either as axed or rubbed arches, and, in addition, the form known as a flat arch [**104**] may be utilised. This is a true arch, being in effect a portion cut



97-108. ARCHES, CENTERING, AND FLUES

out of a larger segmental arch; the joints do not, however, radiate truly, but are formed by dividing both the extrados and intrados into such a number of equal divisions as will result in there being a central voussoir to the arch, and by drawing lines between the two series of points thus obtained.

Forming the Voussoirs. The voussoirs, if made up of two or more bricks in height, are cut or rubbed so as to give horizontal intermediate joints, and adjoining voussoirs are so jointed as to break joint [106]. It will be noticed that in cutting the bricks for a straight arch there is much waste [105], and where the depth of an arch is formed of a header and stretcher the actual depth is usually reduced to about 12 in. In semicircular, segmental, and pointed arches there need be no loss in depth; the width alone is reduced.

In forming the sides of such voussoirs it is usual to cut a groove V-shaped in section in gauged brickwork, so that when two voussoirs are placed in contact a small cavity is formed which will be filled during the process of setting by putty; this will harden, and assists to prevent the bricks from shifting laterally; this is termed a *joggled joint.*

Any such arch may have a moulding or group of mouldings run round the edge. Arches similar in form to axed arches may be formed with purpose-made bricks moulded to the required form, but if arches of various spans are struck with radii of different lengths each arch will require separate forms of bricks. It is desirable to use specially-made bricks for all articles executed in glazed brick, as the glazed surface is apt to be chipped in the process of cutting.

Fireplaces. In forming fireplaces it usually happens in modern houses that the walls are not thick enough to allow of the necessary recess being made in them, and where a fireplace is required the wall has to be thickened. This may be done if the wall is external on the outside [107 C] by projecting the back beyond the outer face of the wall, or on the inside by projecting the front, termed the *chimney-breast* into the room [107 B]; but in all cases where a wall is thickened for this purpose the footings need not be increased in depth, but may have the same number of courses as in the adjoining wall.

In the case of a parting wall, the projection must be into the room, and the back of the recess must be at least 4 in. from the centre of the party wall [107 D]. In the case of an internal wall the projection is usually into the room, and if two fireplaces occur back to back the projection is considerable; if they can be arranged side by side the projection may be reduced, but in such cases the fireplace will not come centrally in the breast [107 E].

In some cases it is convenient to form a fireplace across an angle of a room and two or more may occur in adjoining rooms so as to form a stack [107 F]. On an upper floor a chimney-breast may be corbelled out from a wall, but the extent to which it projects should not exceed the thickness of the wall carrying it [88, page 2724].

Forming the Hearth. The opening itself commences at least 3 in. below the floor level to give depth for a hearth of stone, cement, tiles, or other incombustible material, and the floor in front of the breast is *trimmed* if formed of timber [see CARPENTRY]—except on the lowest floor, where a fender wall may be formed. The space thus formed, which must extend 1 ft. 6 in. at least in front of the breast and 6 in. on each side of the opening, is occupied by a trimmer arch [113], or by a concrete bed supported on angle-irons spiked to the wood joints [111] or on an iron boxing [112].

The Fireplace Opening. The width and height of the opening vary with the kind of grate to be inserted. The top of the opening is rarely lower than 3 ft. from the floor, and may be considerably higher; the width should be at least 1 ft. 6 in. for the smallest bed-room grate, and about 3 ft. is usual, and even more is required, for many grates and ranges.

It is well to make the openings amply large; they may easily be filled in with brickwork afterwards, but it is troublesome to enlarge them. The opening is finished at the top by a rough brick arch, which is usually formed on a wrought-iron cambered bar, termed a *chimney bar,* about 2½ in. wide and ⅝ in. to ½ in. thick. The ends of this should be 9 in. long, and are split, one half bent up, the other down, to build into brick joints. Behind this arch, which carries the front of the breast and is usually only one-half brick in thickness, the sides are gathered over until the width is reduced to that of the flue which is to be carried up [109]. The flue may rise from the centre or from either side, and sometimes a ledge is formed to check down-draught [109 C–C]. In gathering over, the lower edges of the bricks are rough cut, so as to give an evenly-inclined surface. A block of concrete, perforated for the flue opening, may be substituted for the arch and gathering over [109 D–D].

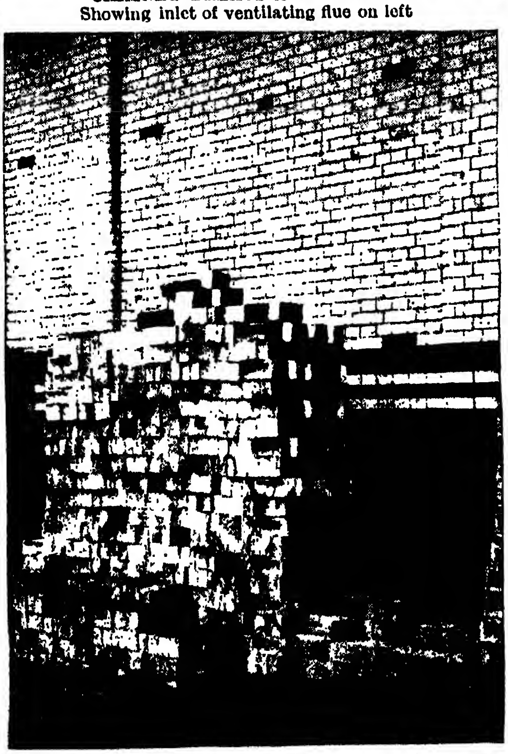
Chimney Flues. Flues are usually 9 in. square or 9 in. by 14 in.—rarely larger for ordinary domestic work, but for the furnaces of hot-water apparatus and large cooking stoves larger flues may be required. They are surrounded throughout and separated from each other by brickwork at least one-half brick thick, and the separating or enclosing wall thus formed is termed a *wythe* [108]; every fireplace has a separate flue carried up to above the roof level. Where several flues occur close together, as when two or more fireplaces occur on a floor in close proximity, or a series of fireplaces are formed on successive floors, one above the other, they are combined into a block termed a *chimney stack* [109]; a special method of bonding is made use of, known as *chimney bond,* mainly composed of headers [108].

In forming flues, which may be carried up vertically, inclined at any angle, and even twisted on their axis if occasion require, great care is necessary to see that the proper sectional area is nowhere reduced; if this occur the flue is said to be *crippled.*

EXAMPLES OF BRICKWORK CONSTRUCTION

CHIMNEY BREAST AND OPENING
Showing inlet of ventilating flue on left

TOP OF CHIMNEY STACK
Showing outlet of ventilating flue



WHITE GLAZED BRICK WALLS AND DARK DADO
Showing bonding of wall and piers and bull-nose angle

CONSTRUCTING HOLLOW BRICK WALLS
Showing iron ties, stretcher bond, and racking brick

Any flue inclined at an angle flatter than 45 degrees requires to be provided with openings fitted with soot doors to facilitate sweeping. These *soot doors* consist of a small iron door and frame which is built into the side of the flue and which, when closed, is perfectly air-tight, but which can be opened for sweeping.

Parging and Coring. As the flue is formed it is carefully plastered on the inside—the process is termed *parging* or *pargeting* [108]; its object is to fill up all joints in the brickwork and to present a smooth, even internal surface to facilitate cleansing. The mortar used for parging usually has cow-dung mixed with it, in the proportion of three parts of dung to one part of lime, which forms a tough material less liable to crack than ordinary plaster. The construction of the flue requires careful watching to see that after parging no mortar droppings are allowed to fall on the finished surface, or, if they fall, are at once removed. The best plan is to block the opening below the level at which work is carried on by a bundle of shavings. On completion the flues are *cored* by passing a stiff wire brush down to clear away mortar droppings. Sometimes a solid wooden ball 8 in. in diameter is passed down every flue to ensure that no crippling has taken place. The top of the flue is often finished with a circular terra-cotta pot; this may be plain and stand only a few inches above the brickwork, its object being to protect the bricks round the top from damage when the chimney is swept; and in some cases flues are lined throughout with similar tubes, and do not then require parging. In other cases ornamental chimney-pots are employed, which may stand nearly their full height above the brickwork. The flat top of the brickwork is finished with a weathered cement surface, here termed *flaunching* [109], completely covering the top of the brickwork and finishing against the pot. Various special forms of pot have been designed to counteract down-draught in the flues, and consequent smoking fireplaces, some of which are of earthenware, but they include tall—sometimes bent—pipes of zinc known as *tall-boys*, formed with a flange at the bottom which rests on the brickwork, and is secured to it; some of these terminate with a rotating cowl.

Smoky Chimneys. It is often difficult to cure a smoky chimney if its condition is due to faulty construction or design, and the following points should be carefully attended to.

The flue must on no account be crippled. No connection with any second fireplace or stove should be made. The flue of a domestic fireplace should not be perfectly vertical throughout its height, but at some point it should be carried over to one side or the other to such an extent at least, that it is impossible to see sky through the flue from the fire opening. The top of the flue should not be finished below the level of the ridge of a high roof, or the wind, when in certain quarters, may sweep over the ridge down upon the chimney and create down-draught. A smoky chimney is not infrequently due to an inadequate supply of air to some other fireplace in which a good fire is burning, which, if unable to draw sufficient quantity of air from other sources, creates a down draught in the neighbouring flue; this may often be remedied by taking an air shaft from the outer air to the neighbourhood of the hearth.

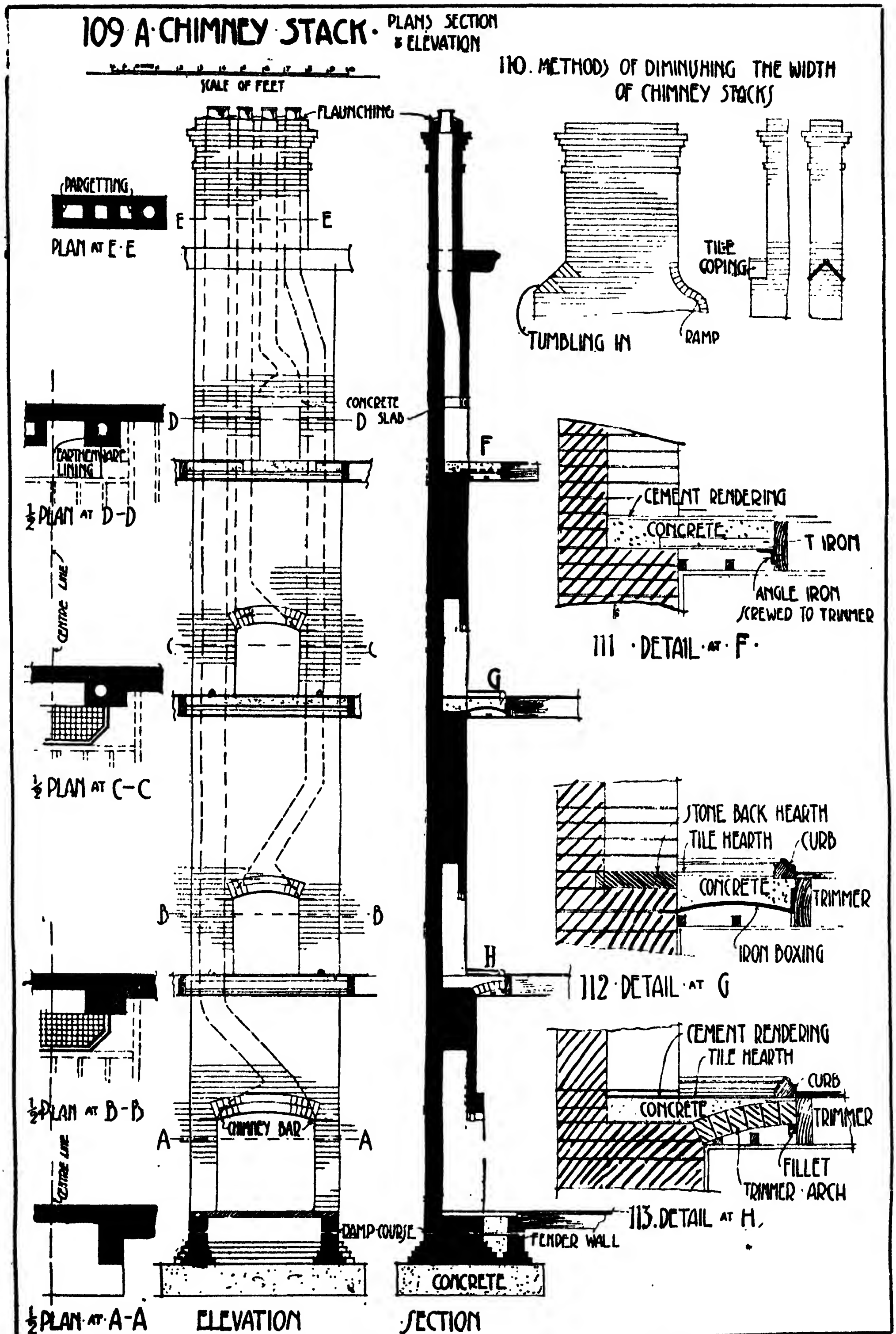
The Use of Dampers. In forming flues from all kinds of furnaces, including coppers, and from kitchen ranges, a *damper* is usually built in; this consists of a sheet of iron the full width of the flue, which usually slides in an iron groove built into it, and when closed entirely blocks the flue; it can, however, be drawn out so as to leave it quite open or be fixed at any intermediate point, thus regulating the draught in the flue, the rate at which the fire burns, and the particular part of the range it is desired, at the time, to heat—*e.g.*, the oven, boiler, etc.

Setting Stoves. The actual stove or grate in which the fire is lighted must be built into the rough opening already described. Such stoves vary much in form; some are entirely formed of fireclay or brick, and most have a fireclay back and sides. They are placed in the recess, and should be set in brickwork, care being taken to fill up the back as well as the front, so that no cavity is left in which soot may accumulate, except in those cases in which a special warm air chamber is formed behind the stove, for introducing warm air into the room. Particular care must be taken to close the space between the front of the stove and the opening, as if this be not properly done smoke is liable to issue from it around the ornamental front or chimney-piece.

Setting Ranges. Ranges vary greatly in form and size. Some are termed self-setting, and merely require to be stood in a prepared opening with the flue pipe taken up into the chimney, the bottom of which may be closed. With many ranges the work is more complicated; they usually include a fire-box, which may be open or closed; and one or more ovens and a side or back boiler. In setting them it is necessary to construct the flue or flues from the fire-box to the chimney, so that the heat from the fire may be directed as desired, either mainly to heat the water in the boiler or to heat one of the ovens; each of these flues must, therefore, be controlled by a damper. This work is best executed in firebrick set in fireclay, but this is not absolutely necessary for small ranges; in all cases it is important that the instructions for forming the flues, which are supplied by the makers of many special forms of range, should have careful attention.

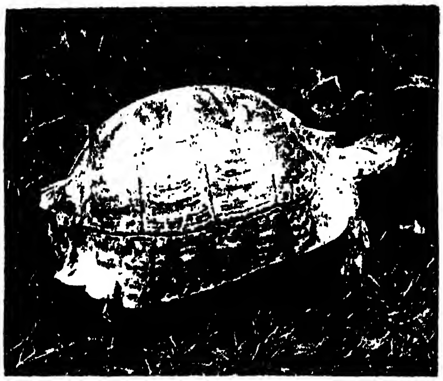
Furnace Flues. All flues from heating apparatus cooking stoves and ranges, except ranges in private houses, and similar flues in which a somewhat fierce and continuous heat is usual, should be surrounded by at least 9 in. of brickwork, and should be formed with firebrick if the heat is great. In most districts the conditions governing the construction of fireplaces, flues, ovens, factory chimneys, and similar works are dealt with by the local building regulations, which should be consulted.

R. ELSEY SMITH

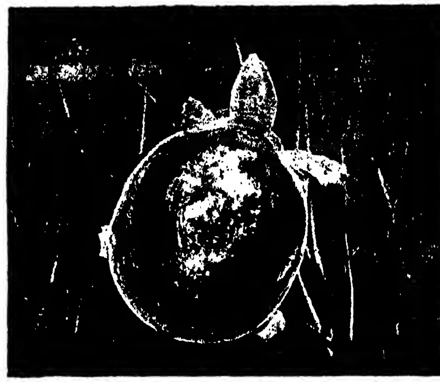


109–113. DETAILS OF CHIMNEY CONSTRUCTION

CHARACTERISTIC TYPES OF REPTILES

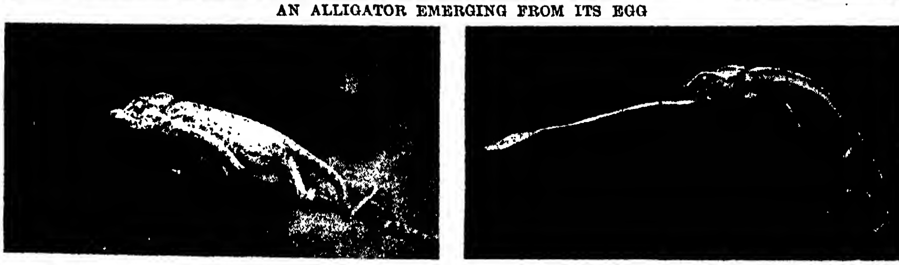


LEOPARD TORTOISE

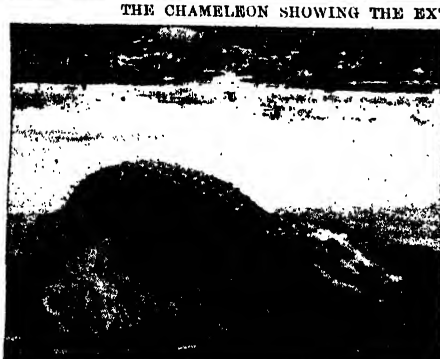


BUNGOMA RIVER TURTLE

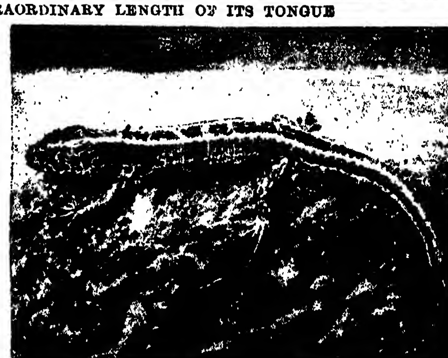
AN ALLIGATOR EMERGING FROM ITS EGG



THE CHAMELEON SHOWING THE EXTRAORDINARY LENGTH OF ITS TONGUE



AMERICAN ALLIGATOR



SAND LIZARD

Extinct Reptiles. Lizards, Chameleons, Snakes, Crocodiles, Tortoises, and Turtles.

REPTILES

REPTILES are cold-blooded vertebrates, in which the pure and impure blood poured into the heart are not kept entirely separate, as in birds and mammals. The limbs, when present, do not (in existing forms) raise the body far off the ground, for the elbows and knees are turned outwards; five digits are typically present in either extremity. The body is covered with horny scales, and there may also be an armour of bony plates in the skin. All reptiles develop from hard or tough-shelled eggs, which in a few cases are hatched within the body of the mother, but are more usually laid in some warm spot. The young, when they first make their appearance, resemble miniature adults, and have to shift for themselves.

Extinct Reptiles. During the Secondary epoch reptiles were the dominant group of backboned animals on land, while some were adapted to a marine life, and in others the fore-limbs were converted into wings. By the beginning of the Tertiary epoch most of the reptilian orders had become extinct, unable, it would seem, to compete successfully with mammals and birds, their own improved relatives. To these extinct types a few words may be devoted. [For details see GEOLOGY.]

Dinosaurs. The very large order of *Dinosaurs*—*i.e.*, "terrible reptiles"—included a great variety of forms, of which some were quite small, while others surpassed all existing land animals in size. Some were vegetarians, others actively predaceous; some lived on the dry land, others preferred swamps, fresh waters, or even the zone between tide marks. While most dinosaurs were quadrupeds, some developed powerful hind limbs of disproportionate length, upon which they hopped or walked about. In such cases the adaptation to progression on two legs brought about certain structural resemblances to birds, but these do not indicate close affinities between the two groups.

Monsters of the Sea and Air. Among the extinct marine reptiles the *Ichthyosaurs* ("fish lizards") were large animals with fish-shaped bodies, paddle-like limbs, and long jaws, abundantly furnished with strong conical teeth. The large size of their eyes indicates that they were of nocturnal habit. The *Plesiosaurs* resembled the foregoing in general shape and in the character of their limbs, but the comparatively small head was borne on a long, flexible neck, which probably had much the same use as that of a swan, enabling its possessor to search for food under water without having to dive.

Even more interesting than the above marine monsters were the extinct *Pterosaurs* ("winged reptiles"), which hunted for their food in the air, and were of most varied sizes. The skin was drawn out into a flying membrane, disposed very much like that of a bat. But while in the latter all four fingers are greatly elongated into slender supports for this membrane, only the little one was so modified in a pterosaur, and formed a strong jointed rod, by which the outer edge of the wing was strengthened. Hence, as already remarked, no less than three totally distinct kinds of flying organs have been evolved by backboned animals—that is to say, by bats, birds, and pterosaurs respectively.

Although so many groups of reptiles have entirely died out, the class is still abundantly represented among existing backboned animals, and the recent species may be grouped into five orders—*i.e.* (1) TUATARAS (*Rhynchocephala*), (2) LIZARDS (*Lacertilia*), (3) SNAKES (*Ophidia*), (4) TURTLES AND TORTOISES (*Chelonia*), and (5) CROCODILES (*Crocodilia*).

Tuataras. This group of reptiles was abundantly represented in the earlier part of the Secondary epoch, and corresponds in many ways to the stock from which reptiles in general have taken origin. It included a number of lizard-like forms, presenting many primitive characters, and now almost entirely extinct, being represented only by the Tuatara (*Hatteria*), which lives on some small islands in the Bay of Plenty, New Zealand. It has only been saved from extinction by the fact that New Zealand became isolated at an early date, so that better-equipped forms have been to a very large extent kept out of these islands.

Lizards. These may perhaps be described as the most average of existing reptiles, and have a very wide distribution. Four small species are native to Britain, and of these the little sand-lizard (*Lacerta agilis*) may often be seen during the summer basking in the sun on banks or scrubby slopes. As long, however, as it remains motionless it is likely to escape observation, for its mottled brownish skin harmonises with the surroundings, and affords a good example of protective coloration. The little animal is capable of very rapid movement, darting quickly upon its prey, which consists of insects, worms, and other small creatures.

Examination of a lizard or its skeleton enables us to grasp very clearly some of the average characters of reptiles, such as the sprawling limbs and long tail. In many instances the last-named member plays an important part in protecting its owner from an untimely end, for it easily snaps across if suddenly seized by an enemy, and time may thus be afforded for escape. There is a weak place in the backbone which makes this somewhat curious procedure possible. Some of the tropical lizards are of very

considerable size, attaining a length of as much as 6 ft., as in the iguanas of America, some of which are esteemed as food. These are among the climbing members of the order, other examples being the geckoes and chameleons of the Old World, both of which are animals of small size. The former have curious pads under their toes, studded with peculiarly shaped hairs, and enabling the owners to scramble up a smooth wall with facility.

A Quick-change Artist. Chameleons are proverbial for the way in which they rapidly change colour if placed among fresh surroundings, so as to harmonise with them. This variable general coloration is protective, because it makes the chameleon invisible to its foes, and also aggressive, as the insect prey of the little lizard are thereby lulled into a sense of false security. The digits are bound together into two groups, and a tongs-like grasping organ of great efficiency is thus constituted. The chameleon is also notable for the relatively enormous distance to which it can suddenly shoot out its sticky club-shaped tongue, for the purpose of seizing insects or other small creatures. Two stages in the process are shown.

TUATARA

Some lizards have become adapted to make their way through dense vegetation by the acquisition of an eel-shaped form, and the reduction or even the complete loss of the limbs. Our harmless native blindworm (*Anguis fragilis*), often mistaken for a snake, is in reality one of the limbless lizards.

Snakes. These reptiles are the most dominant existing representatives of their class, and are closely related to the lizards. They have undergone the same kind of modification in shape and reduction in limbs just mentioned for certain members of that order. The limbs, in fact, have almost always entirely disappeared, except that in a few instances, the pythons, for instance, the hind ones are represented by a pair of insignificant stumps, each of which terminates in a claw.

How Snakes Glide. Upon the under side of most snakes will be found a double series of large, horny shields, to which the ends of the very numerous ribs are attached. By means of appropriate muscles the ribs can be moved so as to bring these shields forward, one after the other, the net result being a rapid gliding motion of progression. One may almost be permitted to say that a snake walks on the ends of its ribs. At the same time the body undulates from side to side—not up and down—in a wriggling or writhing fashion. The extremely flexible backbone permits of this, but to guard against dislocation the vertebræ are connected by extra locking-joints, which only permit a certain amount of play. It is, however, comparatively easy to break the back of a snake by a sharp blow with a stick or whip.

Snakes, like lizards, are very commonly coloured in such a way that they may harmonise with their surroundings, this serving the double purpose above described. A good many poisonous forms, on the other hand, advertise their dangerous properties by brilliant hues and striking patterns. Such "warning coloration" is seen, for example, in the coral snakes of tropical America, which are marked with broad red rings, alternating with others of whitish tint, shading into black at the front and back of each ring. These coral snakes serve as models which certain harmless forms unconsciously mimic, thus securing a certain amount of immunity from attack by sailing under false colours.

Snakes that Warn. In the American rattlesnakes, at each periodical casting of the skin or slough, a little knob remains at the end of the tail. A series of these loosely united together make up the "rattle," used for the production of warning sounds. The "hissing" of a snake has the same purpose. Venomous snakes also commonly assume a warning attitude, raising the front part of the body from the ground and, in some cases, as illustrated by the cobra, inflating a kind of hood—in this particular instance bringing a black, spectacle-shaped mark into prominence.

But in these and other animals it must not be supposed that the "warning" is for the benefit of the prey, but may be taken as a hint to aggressive birds and mammals that discretion is the better part of valour. The success of this device is shown by the terror with which all monkeys regard serpents.

Abnormal Feeding Capacity. Snakes are essentially carnivorous, and, with the exception of some small, degenerate forms that pursue earthworms underground, are able to swallow animals which are very much larger than themselves; this gluttonous procedure often bringing its own punishment, for the state of lethargy which succeeds the bolting of

a meal affords a favourable opportunity for the onslaught of enemies. Feeding in this way is rendered possible by the extreme power of dilatation the body possesses, which is partly due to the absence of a breast-bone and shoulder-bones. The two bones of the lower jaw are not firmly united, as usual, at their tip, but merely connected by an elastic ligament, which easily stretches. To prevent choking during the tedious process of swallowing, the top of the windpipe is drawn out into a long cone, which temporarily protrudes from the side of the mouth.

Non-Poisonous Forms. A large number of snakes are non-poisonous, and these possess numerous conical backwardly pointing teeth on the edges of the jaws and roof of the mouth which are of no use for chewing, but hold the prey firmly and prevent its escape. Our common native grass-snake (*Tropidonotus natrix*) is a good example of such forms. It is particularly fond of the neighbourhood of streams, and is an expert swimmer. Its favourite food consists of frogs and fishes. Innocuous snakes also include the largest members of the order—that is, the boas and pythons of tropical America, which crush comparatively large mammals into a shapeless mass that is gradually swallowed after lubrication with the abundant saliva.

THE SPECTACLED COBRA

Poisonous Forms. In venomous serpents some of the glands opening into the mouth secrete a poisonous fluid, which is introduced into the blood of a bitten victim. The largest amount of specialisation is found among the vipers, where the teeth are reduced to a pair of hollow "fangs" in the front of the upper jaw, and there are two large poison-glands, one on either side of the head, giving it a characteristic resemblance to the ace of spades. The mere shape of the head is however, no certain test as to the venomous or innocuous character of any given form.

THE FANGS AND TONGUE OF A POISONOUS SNAKE

In a state of rest, when the mouth is shut, the poison-fangs are pressed against the roof of the mouth, with their tips directed backwards. But when the snake opens its mouth and "strikes" the fangs are rotated forward, so that their sharp tips can be brought into action. The poison flows into the upper end of the tooth-canal and, in vipers, enters the wound by a small hole on the side of the tip. Were it at the end a blockage might result. We have, in fact, an anticipation of the device used in the construction of the needles employed with hypodermic syringes.

It may be well to call attention to the external characteristics of our only native poisonous snake—that is, the adder (*Pelias berus*), which is a species of viper. It is particularly common on sandy moorlands. Besides the spade-shaped head, note the dark, broad, zigzag stripe on the upper side of the body.

The Cure for a Snake-Bite. A venomous serpent is not poisoned by the absorption of its own poison, because its blood contains a complex "defensive proteid" which renders this harmless. It is fortunately possible to make an artificial extract of this substance for given species, which appears to be the only certain cure for the more virulent forms of bites.

It may not be superfluous to remark that the forked tongue of a snake, which can be shot in and out with great rapidity, is not a "sting," but a very delicate organ of touch. It also possibly serves to attract the attention of victims by exerting a sort of hypnotic influence—the so-called "fascination." It is at least certain that small mammals and birds often seem as if they were paralysed on the approach of one of these insidious foes, and make no efforts to escape.

Though naturalists do not know of any marine animal corresponding to the legendary "great sea-serpent," or kraken, a number of aquatic snakes inhabit the Indian Ocean, though these are much too small to be the origin of the myth. Some of them have the tail flattened from side to side for use as a propeller, and all are extremely poisonous.

An Egg-Eating Snake. One kind of snake (*Rachiodon*) has discovered the nutritious properties of a diet consisting of birds' eggs, and is possessed of a curious arrangement in connection with this. A tooth-like spine pro

jects into the throat from the under side of the backbone, and this acts as an egg-breaker, the contents of the egg being swallowed while the shell is ejected from the mouth.

The hieroglyphics of the ancient Egyptians constituted a system of picture writing, in which the characters were outlines of various objects. One of these was a snake lurking in the desert sand, and distinguished by the presence of two little horns on the head. In course of time the cumbrous hieroglyphics were simplified, and the drawing of the horned snake became V_____ (the horns and body). By loss of the horizontal stroke our letter V has come into existence.

The Wisdom of the Serpent. In correlation with the presence of a well-developed brain, snakes may be regarded as the most intelligent of reptiles, though the idea of their "wisdom" probably took origin in their stealthy ways, and the curious "fascinating" powers already mentioned. They are among the numerous animals that have been the objects of superstitious worship.

Some snakes incubate their eggs, and show a certain amount of affection for their offspring —though they are far excelled by birds and mammals in this respect.

Crocodiles and Alligators. These inhabitants of the rivers and estuaries of tropical regions are somewhat lizard-like in appearance, but in structure they are in many ways much more specialised. The snout is armed with powerful interlocking teeth, which constitute a deadly trap. The valvular nostrils are on the top of the snout, so that the animal can drift along with most of its body submerged, and at the same time breathe quite easily. Should it perceive an unfortunate mammal drinking or browsing on the edge of the bank, it sinks below the surface, and rapidly swims towards the victim by strokes of its powerful, flattened tail. Then comes a sudden snap, aided, perhaps, by a lash of the tail; should the attempt prove successful, the prey is held under water till it is drowned, if too large to be forthwith swallowed.

Breathing Apparatus. The crocodile itself is not choked during this procedure, because it is in possession of a structural arrangement comparable to those described elsewhere for whalebone whales and newly born pouched mammals, such as kangaroos. The internal openings of the nose (internal nostrils) are very far back, and the top of the windpipe is drawn out into a projection wrapped round by folds so as to project into them. There is no danger, therefore, lest water, after entering the mouth, should enter the lungs.

In some crocodiles—namely, certain species inhabiting the Ganges—the food consists of fish, and here the snout is very long and narrow, as in the fresh-water dolphin of the same river. Comparison may also be made with one of the extinct toothed birds (*Hesperornis*) of the chalk period. In all cases a very efficient seizing apparatus results, well adapted to deal with the slippery prey.

Peculiarities of Structure. There are many other points in which the structure of these reptiles presents points of interest. The body, for instance, is not only clothed with strong, horny scales, of which those on the upper side of the tail make up a saw-edged ridge, but also defended by bony scutes in the skin. The stomach is not unlike that of a bird, part of it being converted into a muscular gizzard, the crushing action of which is enhanced by stones or other hard objects which are swallowed from time to time. The organs of circulation are also of great interest, for the heart is four-chambered, as in mammals and birds, and not three-chambered, as in other reptiles and amphibia. The pure and impure blood do not, therefore, mix inside the heart; but as such blending takes place outside, owing to imperfect separation of the great vessels, the net result is much the same as in the lizards. But it may be said that crocodiles are well on the way to become warm-blooded animals, and they are also more intelligent than other reptiles, in correspondence with their larger and more complex brain.

Tortoises and Turtles. This widely distributed order includes a great variety of forms adapted to live under the most varied conditions. Some are vegetarians, others flesh-eaters, but in all cases the teeth are replaced by a strong, horny covering to the jaws, making up a sort of rounded beak, which is hooked in the carnivorous types.

Remarkable defensive armour is, however, the most characteristic feature. The body is, as it were, sheltered in a strong case, consisting of an upper shield (*carapace*), which is more or less united at the edges with an under shield (*plastron*), to make up a sort of box, giving a remote resemblance to the arrangement present in armadilloes among mammals. The outer layer of the case is composed of horny plates, which in certain marine species are the source of "tortoiseshell," and beneath these are bones, some of which are derived from the backbone and ribs. At the front and back of this case are deep hollows, into which head, tail, and limbs can be withdrawn. The neck is exceedingly flexible, which compensates (as in birds) for the rigidity of the trunk.

Gigantic Tortoises. In land tortoises the extremities are stumpy and well suited for progression on a firm surface. It is particularly interesting to notice that, in the absence of severe competition, some of the tortoises living on isolated islands have attained a large or even gigantic size. This applies to some of the islands of the Indian Ocean, and also to the Galapagos Islands, situated on the equator to the west of South America. The gigantic tortoises of the latter were described by Darwin in his account of the voyage of the "Beagle."

In marsh and fresh-water tortoises the limbs are more or less flattened out to serve as paddles, and this modification is carried to an extreme in the thoroughly marine turtles, where the limbs are in the form of powerful flippers.

J. R. AINSWORTH-DAVIS

Electric Furnaces for Metallurgical Work. Production of Aluminium, Steel, Phosphorus, Calcium Carbide, and Nitrates. Electric Welding.

THE ELECTRIC FURNACE

A most important industrial application of the principles set forth in the early part of the last chapter is found in the *electric furnace*, by means of which much higher temperatures than that of the ordinary coke or charcoal furnace may be obtained.

Applications of the Electric Furnace. The applications of the electric furnace are two-fold—namely (1), in processes which of necessity require a temperature higher than that which can be obtained with the ordinary furnace (which is about 2000° C.); and (2) in others which are workable also at lower temperatures, but in which the electric furnace is so compact that the cost of production is much reduced, and in which there are no products of combustion to carry away the heat.

Types of Furnaces. The furnaces themselves may also be divided into three classes—namely, those in which the heating is done by the aid of resistance; those in which an electric arc is formed, and is allowed to play on the contents of the furnace; and those in which large currents are inductively produced and used to heat up the material in the furnace. Many types of furnace are a combination of the above actions.

The uses to which electric furnaces are put are now so numerous that it is impossible to describe them all. A few typical examples will illustrate their utility and adaptability.

The Electric Hardening Furnace. This is a simple resistance type of furnace which has been developed by the A. E. G. Company, of Berlin, for the purpose of hardening steel tools. Fig. 228, showing a complete installation, illustrates the convenience and cleanliness of this method of heating. The bath, or furnace, consists of an iron case lined with a heat-insulating compound. The interior is partly filled with mixtures of metallic salts, such as barium and potassium chlorides. These have their definite melting-points below the temperature to which the tool under treatment must be heated, and remain liquid to temperatures higher than the maximum required.

The equipment consists of a switchboard with a few regulating switches and instruments, and a transformer which converts the alternating current from the voltage of supply to the working pressure of the furnace. When required for use, the current is switched on; and to start the furnace the carbon point shown in the illustration is made to touch the opposing electrode. An arc is thereby formed which soon melts part of the solid salt; and as soon as the melted portion touches both electrodes the mass becomes conductive, so that the whole is soon in the fluid state. Measurements of temperature are taken with a pyrometer, and by regulating the flow of current the bath temperature is kept constant.

Tools to be hardened are suspended in the bath a sufficient time to reach the known bath temperature, and are then quenched in cold water, or in brine, or in a cold air-blast. This process is rapidly superseding other methods in the best machine-tool works in the world.

Moissan's Arc Furnace. The simplest form of arc furnace is that devised by Moissan in France. As shown in 226, it consists of two blocks of chalk carefully dried, and carved out so as to form a cavity in which a carbon crucible can be placed. Massive carbon rods pass into this cavity from opposite ends of the furnace, and the arc formed between them plays over the crucible, heating the material under treatment in the manner of the reverberatory furnaces.

Moissan was able readily to melt even the most infusible of metals, such as platinum and iridium, and has shown that gold is not only melted, but boils, giving off a purple vapour. The use of this furnace is preferred in the production of metals, alloys, and the like which are themselves too conductive to be conveniently used in resistance furnaces.

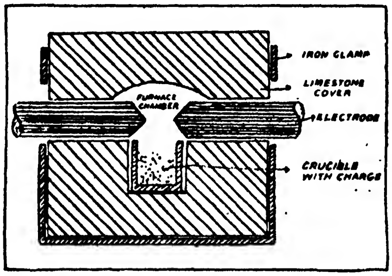
The Manufacture of Aluminium. Practically the whole of the aluminium used in commerce—about 50,000 tons annually—is produced electrically. Although known for many years, it was not till electrical methods of obtaining it were perfected by the Brothers Cowles, in 1884 and 1885, in America, that its use was generally spread. It is now produced wherever cheap power is available; and the British works at the Fall of Foyers in Scotland, the American works at Niagara, the Swiss at Rheinfelden, all use water power as the prime mover.

The process used is to make in the first place pure alumina—hydrated oxide of aluminium—from either cryolite or bauxite, two mineral ores containing aluminium, and then to dissolve this powder in fused cryolite while passing a current of electricity through the solution. The furnace consists of a cast-iron box, lined with carbon, having at the bottom a cast-iron plate, which forms one electrode. Suspended above is a bundle of carbon rods, adjustable as to height and consequent immersion in the furnace.

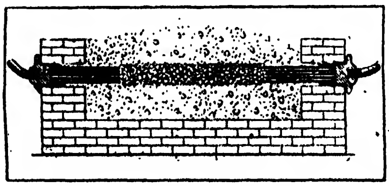
On starting, some cryolite, or a similar mixture, is placed in the furnace. This melts at a comparatively low temperature, and is then capable of dissolving about 20 per cent. of alumina, which is constantly supplied to the furnace. Current is supplied at from three to five volts, about 8000 amperes being required for a modern furnace. The temperature in the furnace is about 800° C.

Not only pure aluminium but a number of valuable aluminium alloys can be made in furnaces of this type.

Phosphorus. This is another substance which is now largely produced electrically. The old way was to place small retorts containing the necessary mixture of phosphates and carbon in an ordinary furnace. In 1888, however, Readman and Parker perfected an electrical process which has come into extended use. The mixture employed is composed of a mineral phosphate, sand, and carbon; and the principal feature of the furnace, which is of the resistance type, is the care which has been taken in its design to exclude all air. The mixture is supplied to the furnace by a small spiral conveyor, and an opening at the side of the furnace permits any fumes to escape. Another type of furnace, based on the arc principally, in which the phosphorus is expelled from the furnace in the form of vapour, has been invented quite recently by Dr. Machalska, of New York.



226. MOISSAN'S ARC FURNACE


227. CARBORUNDUM FURNACE

Calcium Carbide. This substance has come into extensive use by reason of the ease with which, when mixed with water, it produces acetylene gas. It is made by heating together a mixture of 65 per cent. of lime with 35 per cent. of carbon, or coke, to a temperature of not less than 3300° C. (6000° F.). At this temperature the oxygen of the lime is driven off, and the calcium combines with the free carbon. One pound of good carbide gives in the presence of water about five and a half cubic feet of acetylene gas.

Two forms of furnace are in use, one in which the process is continuous, and the other in which it is intermittent. In the former the materials are fed down a funnel on to a hearth, where they are converted into the carbide, this being drawn off in the liquid state as it is formed. As calcium carbide solidifies at a high temperature, difficulty is experienced in devising arrangements for drawing off the carbide, so that a more usual way of manufacture is to feed the materials slowly into a bin with metal sides, and as the carbide is formed to raise the electrode, so that in the end a solid block of carbide is withdrawn from the furnace and a fresh charge introduced. The carbide obtained in this way is liable to contain portions of uncombined lime, and so forms the cheaper qualities on the market.

Carborundum. This is a compound of carbon and silicon—known chemically as silicon carbide—and is made in a furnace such as is shown in **227.** It consists of a rough brickwork structure, which can be taken down and reconstructed for each run, and is designed merely to keep the raw materials together. Each electrode is formed of a bundle of carbon rods set in a metal holder to which the leads are attached. Between the ends of the electrodes there is built up a core of broken coke, around which the charge, consisting chiefly of coke and sand, is packed.

A furnace about 24 ft. long, 5 ft. 11 in. wide, and 5 ft. 6 in. deep will produce about 3·1 tons of carborundum every 36 hours, with a consumption of about 750 k.w., corresponding to 3·86 units per lb. of carborundum. The voltage drop is from about 200 volts to 75 volts, and the current towards the end of the operation is 8000 to 10,000 amperes.

Calcium Cyanamide. The partial exhaustion of the guano deposits in Chili, and the incurring world-need for nitrogen manures, have caused special attention to be directed to the subject of using as fertilisers nitrogen products made from atmospheric nitrogen [see page 307].

There are at present two successful methods in use, one of which is by the manipulation of calcium cyanamide ($CaCN_2$). This substance decomposes in the presence of water into calcium carbonate and free ammonia. If the substance is distributed over the ground, the change goes on slowly, the ammonia being absorbed and fertilising the ground. It is made by taking calcium carbide—produced as mentioned above—powdering it, and placing it in retorts holding about 6 cwt. each. These retorts have cardboard tubes down the centre, and cardboard partitions. The retorts are sealed up and heated electrically by means of an alternating current to about 800° to 1000° C. The cardboard is burnt out, and nitrogen gas, admitted under pressure, circulates through the mass, converting it in about forty-eight hours into calcium cyanamide. At Odda, in Norway, electrical power costs 30s. per e.h.p. year, and 196 furnaces are at work, producing about 30 tons per twenty-four hours.

Other Nitrate Products. The other method of using, for fertilising purposes, atmospheric nitrogen is the direct production of nitric acid and of nitrate of lime. The Birkeland-Eyde process has been perfected at Notodden, in Norway, where about 60,000 h.p. is available from waterfalls, and at the Rjukanfos, another waterfall in Telemarken, where no less than 300,000 h.p. is available.

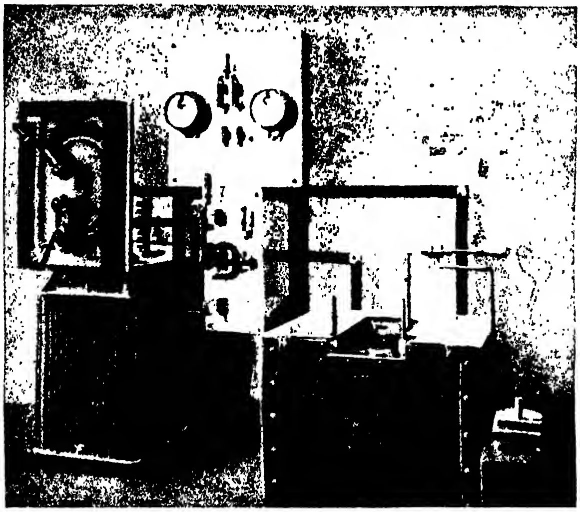
The operation is carried on in a sheet-steel furnace, about 8 ft. in diameter, lined with refractory fire-bricks. There is a disc-shaped space in the centre, about 6 ft. in diameter. The electrodes consist of copper tubes which have water circulating within them to keep them cool. The arc is produced by means of a powerful alternating current, often 500 amperes at from

3000 to 5000 volts. This forms a powerful electric sheet of flame playing between the two electrodes. A continuous current excites an electromagnet, the poles of which enter the furnace axially, forming a powerful magnetic field between the two electrodes. The joint effect of the magnetic field and the alternating current is to produce a sheet of flame of very high temperature—at least over 3000° C. Air is gently blown through this furnace, and in the high temperature of the arc about 1 per cent. of the nitrogen in the air combines with the oxygen, and forms nitrous and nitric oxides.

The rest of the process consists in cooling the gases and extracting the nitrogen oxides from the treated air. This is very carefully done, and the nitric acid produced is concentrated and sold, or else is converted into nitrates of lime by absorption into beds of lime. Some of the furnaces in use are of 3000 k.w. size, and the nitric acid and nitrates thus produced are finding a ready sale. A modification of this process, introduced by Schoenherr, uses a thin, very long drawn out arc, in furnaces 15 ft. to 20 ft. long.

The Electrical Production of Steel. Until a few years ago, the only application of the electric furnace to steel-making was in connection with the manufacture of tool steel. The ability to make such steel homogeneous in texture and free from gases brought the electric furnace into prominence. The past six years have, however, seen the placing on the market of electrically produced steel castings which are looked on with favour because of their high quality and freedom from blow-holes. Electrical methods have made it possible, too, to make the highest qualities of steel from the cheapest raw materials. It is not strange, therefore, that great attention is now paid to the subject, and that large electrical furnaces are being built in all parts of the world.

The furnaces which are used in steel manufacture are of various types. The early patterns were arc furnaces, and to this class belong the Stassano, Heroult, and Girod forms. The Heroult furnace, which is still largely used, has carbon electrodes placed at an angle over the furnace level, and playing over the furnace of the material. In the Girod furnace, one of the electrodes is at the bottom, and the arc is formed between a number of carbons placed over the furnace and the surface of the material.



228. ELECTRIC HARDENING FURNACE

The Kjellin, Frick, and Rockling-Rodenhauser furnaces are of the induction type. In them the iron hearth of the furnace, together with the material upon it, forms the secondary circuit of large transformers. The eddy currents set up in this mass of material raise the temperature to a very high degree, which is under control by varying the current in the primary winding. In some furnaces there are also windings on the secondary, which pass currents through electrodes to the mass under treatment, in this respect acting as a resistance furnace.

The experience which is now rapidly being gained is resulting in a very high return in quality of finished steel and in the reduction of the electrical energy required per ton of steel made. Though the electric furnace is not yet a serious rival to the older methods its advantages in the way of an improved product—the composition of which is easily controllable—coupled with the fact that cheap power, rather than cheap coal, is an important factor in the location of the works, will no doubt lead to its extended use in steel manufacture.

Electric Welding. In one method, introduced by Professor Elihu Thomson, in America, a special transformer is used, having very low voltage secondaries, supplying correspondingly large current. The ends of the wires or bars to be welded are connected in the circuit of the secondary circuit, and pressed mechanically together. Intense heat is produced at the junction, owing to the electrical resistance of the joint; and as soon as the metal is softened by the heat the pressure causes them to weld securely together.

Power for Electric Furnace Work. It is stated that in a recent year (1909) 362 million units of electric energy were sold at Niagara, and of this amount 322 million units went to thirty-three electrochemical and electrometallurgical works, at an average charge of 0·133d. per unit. For many of the electric furnaces, alternating currents are essential. This is advantageous, because while large alternating current generators are cheaper to make, the energy, when produced, can more easily be transformed from one voltage to another Most electric furnaces, to be worked profitably, must be kept going day and night without stoppage, since the load-factor must be kept as high as possible if the cost of the supply is to be low.

SILVANUS P. THOMPSON

Three and Four String Basses. Attitude. Tuning. Fingering. Scales. Intervals. Time. Positions. Pizzicato Effects. Harmonics.

THE DOUBLE-BASS

Too much importance can scarcely be attached to the double-bass in an orchestra. It doubles the bass part of the violoncello and is the literal foundation, or "base," upon which rests the entire instrumental superstructure. It is easy to understand, therefore, why the smaller bowed instruments should be named after the great violone.

Three and Four String Basses. There are two kinds of double-basses in general use. They are known as the English and the German. The former is provided with three strings, an arched bass-viol bow, and is capable of great power; whereas the latter has four strings, and a straight bow of 'cello pattern is used with it. Modern composers write chiefly for the four-stringed bass, because it can descend a fourth lower in tone than the instrument with three strings. The temptation of getting four additional bass notes, rather than consideration for tone quality, has been the chief cause of the general adoption of the German system of stringing.

Execution and Tone. But the fact remains that a good player on the triple-strung English bass can elicit a more telling tone from it with the old-fashioned bow than can the performer on its quadruple-strung Teutonic cousin. Advocates of the four-stringed bass emphasise that certain Italian makers originally planned the biggest pattern of fiddle to carry four strings. They argue that the restoration of the fourth should not lessen the tone of the other three. But they conveniently overlook the fact that the reduction of the six strings to four on the treble viol, during its evolution into the violin, immensely enriched its tone.

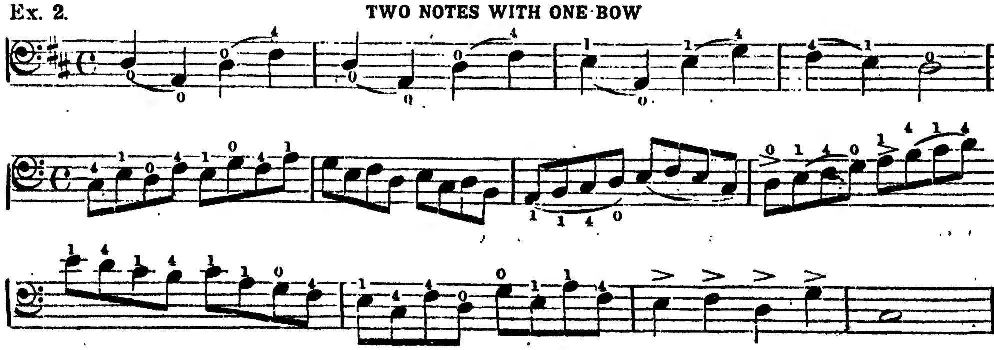
The beginner, whatever he does later on, had better first learn the English double-bass with three strings. An instrument of fair tone is obtainable in Great Britain, nowadays, for about £5. As soon as the student is able to help in an orchestra, he will find that, like the kettledrums, the society generally provides an instrument for the double-bass player. Excepting in large professional orchestras, such basses have three strings. So useful are amateurs who can play this instrument with tolerable reliance, that, in many societies, not only is a bass hired for them, but they pay a smaller annual subscription than the other members.

Attitude. On account of the size of the double-bass, the performer stands to play. During lengthy practice a useful support will be afforded by the ledge of a high stool. Grasp the neck of the bass near the head. place the first finger of the left hand on the middle string, put the thumb on the opposite side of the neck immediately underneath, and rest the third and fourth fingers on the third string. Place the left toe under the bottom edge to keep the bass at its proper angle. Suppose the bridge of the instrument represents the centre of a clock-dial and the neck its long minute hand; if the latter points to the hour of one, the angle is correct.

With the right hand take up the bow. Put the thumb on the hair inside, and near, the nut. Rest the other fingers above the thumb on the stick. The instrument being

Ex. 1. *Very slowly.*

Ex. 2. TWO NOTES WITH ONE BOW



at an angle to the player's body, it would be awkward always to bow parallel with the bridge. It is therefore customary for the bow to incline downwards towards the bridge from the third to the first string. The point of the bow, when on the first string, should be just over the top of the left sound-hole.

Tuning. Even as the pitch (A) of the first string on a violoncello is an octave below the pitch (A) of the second string of the violin, so the harmonic A of the third string of the English double-bass can be tuned an octave below the A, or first string, of the 'cello. As this A is a very deep note on the bass, it is better to begin with the first string. Tune this in unison with the G, or third, string on the 'cello. If the pitch is taken from a piano, tune to the G, fourth space, bass clef. Instead of scraping forcibly, a less distracting method is to place the tips of the fingers of the left hand lightly on the middle of the string.

Harmonic Sounds. This plan, when the note is bowed, will give the harmonic, an octave above the actual open sound. Having raised or lowered the peg of the string first until the harmonic is in unison with the tone of the fourth string of the violin (G, fourth space, bass clef, on the piano) take the hand off and bow the string. Its open sound will then be G, first line, bass clef. This gives what is known as the tone of an 8 ft. organ pipe. Tune the second string to D, in the same way by the harmonic, a fourth below the first. Lastly, tune the third string to the 16 ft. A, a fourth below the D. This is the English method with the three-stringed bass.

Unfortunately, there are other systems. Although violins, violas, and 'cellos are uniformly tuned to the same notes in different countries, the French tune their three-string basses in fifths instead of fourths. This is awkward for the hand. In France, therefore, in place of the first string being G and the third A, the first is A and the third becomes G.

The beginner is warned not to adopt the French method nor to lower the A string to G, as is often done. When the double-bass is tuned, English fashion, in fourths, the scale lies under the hand more conveniently. Moreover, when progress has been made and the student takes up the four-stringed bass, he will find that instrument also is tuned on the first, second, and third strings to D, G, and A in the way he has learnt. The new string will then be E, at a similar interval of a fourth lower down the scale.

Fingering. The reason why tuning the bass in fourths instead of in fifths, as obtains on the 'cello, viola, and violin, is more convenient is because of the greater length of the strings. These necessitate longer stretches of the left hand for stopping the ascending or descending notes. Thus, when four fingers are placed close together they represent the natural position, or an interval of a half-tone. If, on the other hand, the fingers are spread out, they occupy the space necessary for stopping the interval of a whole tone. The student who grasps this idea has the fingering of the double-bass in a nutshell. When the notes do not occur on an open string, they are usually produced either by the first finger singly, or all four fingers together. In double-bass music, these methods of fingering are indicated by Exs. 1 and 3.

Play the open note of the third string, A. Use the bow from end to end. Count ten slowly. Then place the first finger firmly on the same string; at the same time sound the note B with a full bow. Close the four fingers to get the half-tone above, and with the next bow play C. Without pause, sound the open note of the second string, D. Play the E above with the first finger.

But the pupil will perhaps say that it is the E below. It must be remembered that the expression "up" or "down" the fingerboard of the double-bass refers to the ascent or descent of the tone; it does not relate to the direction in which the scroll of the instrument points. With the four fingers closed to make the semitone "above" E, play F. Continue on the first string, sounding the open G. With the first finger get the A above. Separate the four fingers for the whole tone B. The beginner will now have played a full octave and one note. Descend the scale by stopping each interval in the same manner.

By changing the order of these notes, the student can familiarise himself with the different intervals by a variety of exercises. Practise these very slowly at first. Cultivate a good tone rather than a rapid execution, especially in the lower register of the instrument. To play the double-bass well requires muscle. It is excellent for one's health, because it expands the chest, strengthens the arm and wrist—in fact, professional double-bass players are noted for living longer than any other class of musicians.

Not a Transposing Instrument. In writing out exercises, the student will note that all sounds for the bass are indicated an octave higher than their real pitch. Not only does this facilitate the reading of double-bass music, but it allows the 'cello and double-bass parts to be indicated by the same notes, those for the former instrument having their tails turned up, and those for the latter their tails turned down. It is incorrect, therefore, to call the double-bass, as some pedagogues are fond of doing, a "transposing" instrument. Unlike the A♮ clarionet, or E♭ trumpet, which transpose their sounds mechanically to other regions of pitch, the double-bass always emits similar sounds to those written. The player, therefore, who is a purist, has only to imagine the words "8ve lower" written over the bass part to satisfy his conscience. If, as sometimes happens, a composer writes below the possible compass of the double-bass, the critic can then mentally obliterate the words referred to. The double-bass will do its best by putting in the notes in unison with the 'cello.

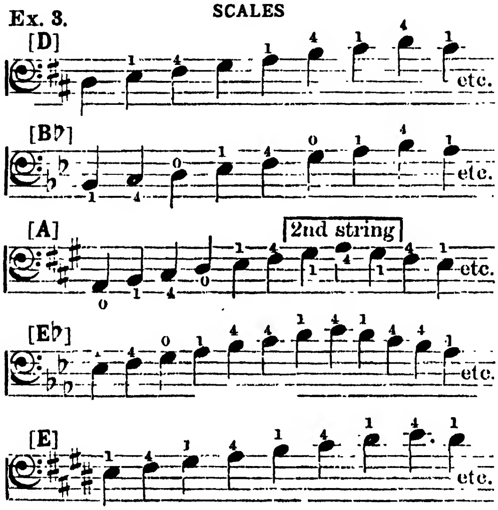
The Scales. Now take the scale of G major, with one sharp, F. Begin with the open note on the first string. Spread out the four fingers on the second string to get F♯, instead of closing them, as was done for F♮. With the

first finger, make the next note, E. Then sound the open D. Bow slowly. Count, so as to make each stroke equal. With the four fingers closed on the third string, stop the C. Make the B, half a tone lower, with the first finger, and the A with the open note of the third string. This does not complete the octave, but it accustoms the player to the F♯ on the second string.

Try the scale of C major. Begin with the four fingers closed on the third string. As before, get the D and E on the second string. For the semitone F above, close the four fingers. As previously, make the G and A on the first string. Separate the fingers to get the B, a whole tone above. To play the C, a semitone beyond the natural position of the hand, shift the latter up the neck (or down, in a gravitational sense) till the four fingers, close together, stop the sound.

Alternative Fingering. There are alternative methods of fingering these same notes. The student should familiarise himself with them. We refer to the first string, from G, fourth space, to the C above and back again. First, there is the fingering already indicated. Secondly, play the open string. Then stop A with the first finger. Carry up the same finger to stop B. Next, with all four fingers close together, play the semitone C above. Return in the same way. The usual plan is to play these notes, interchanging the first with the four fingers, by stopping the A with the first finger, the B with the four fingers, the C with the first finger, going back to the four fingers for B and the first finger for A. But this system carries the whole hand higher than necessary up the fingerboard. In double-bass playing, one of the arts is to avoid wasting energy by superfluous shifting of the left hand. Besides being unsightly, it is fatiguing. It makes the performance uneven instead of, as it should be, firm and clear.

Ex. 3. SCALES



Hand Movements. Remember, therefore, not to move the whole hand about unprofitably. Practise slowly, and restrain the desire to run before learning to walk. So that the hand may come into its right place without thinking about it, and passages may be fingered readily and correctly, the student must be careful to be right in his first attempts. The road to success is by regular daily practice. A steady quarter of an hour of slow, strong bowing three times a day, with intervals in between, does more good than an hour's unbroken practice, during half of which time the beginner may feel over-tasked by the unaccustomed strain on his muscles.

To continue the double-bass when fatigued and the hands are aching is unwise. At such a time, stop practising and give the muscles a rest. Then, with recovered strength, try again.

Now try the scale of D major with two sharps, F and C. Begin on the second string. Bow the open D. With the first finger get E above. Put down the four fingers spread out for the F♯. Sound the open G of the first string. Whether the bow makes a downward or sideway movement, take care to keep the right wrist free. Although, later on, the straight bow of 'cello pattern may be used, the student who practises with the arch bow should be able to get a greater amount of force of tone from it and attack the strings better.

A Lissom Wrist. But the effect will be spoilt if this is done with a stiff wrist. The wrist action must be unconstrained. Dragonetti considered the arched bow superior to that with the straight stick, and the pupil cannot go far wrong who uses a bow similar to that of the great Venetian double-bass player, who educated himself in the guitar and violin, and was able to take a place in an orchestra at the age of eleven. From that period he played the double-bass continuously for no fewer than eighty years, never getting tired of it, but always revelling in its beauties.

Having bowed the open G properly, put down the first finger for A, spread out the four fingers for B, stop with the first finger the C♯, a whole tone above, and put down the four fingers closed for the semitone D. Descend the scale with the same fingering.

Intervals. Proceed now to practise the intervals of thirds, fourths, and fifths. First get accustomed to these in the key of G. Note down all such exercises on paper, and transpose them into C major and D major. By such means the student will get an insight into the elementary principles of bass playing. We give specimens of exercises that can be easily supplemented. "U" denotes the up-bow, and "D" the down-bow [Ex. 1].

Next, practise the major scales which have up to four flats and five sharps in their signatures [Ex. 3].

To acquire facility in the necessary shifts of the left hand up or down in diatonic passages, persevere day by day with the exercises given in Ex. 2 till they become automatic.

Bowing. Now go back to the scales. Play every two notes with one bow, then every three notes with one bow. Making the tone as smooth as possible, try to get every successive four notes with one bow. Play alternately with an up and down stroke. Determine to

make the voice of the instrument, deep as it is, sing out evenly with a cantabile effect.

Staccato. That method of bowing which is the reverse of cantabile is done by separating each note abruptly. It thus appears to be detached, although the bow is not taken off the string. This is called staccato playing.

Practise the scales systematically, repeating each note so as to make two short, abrupt sounds with each bow instead of one long one. Next make three short sounds with each bow. Then alternate the cantabile with the staccato style, by slurring the first pair of four notes with an up-bow, and making the next pair crisply with a down-bow. Write out these exercises on music paper, and go over the same ground day by day.

Time. It is necessary for the student, when practising even the simplest studies, to cultivate a sense of time. The double-bass is called the metronome of the orchestra. It is essential, therefore, for the player of this instrument to be a good timist; and to be a good timist he must possess confidence. No double-bass player who distrusts himself can reasonably expect the confidence of others. The glory of the double-bass player is in his strength, and, as hesitation is a sign of weakness, if he hesitates he is lost. If he plays irresolutely, he may upset all the other performers. Cultivation of the time sense gives certainty to the student's playing. It is more important to attack emphatically the first note of a bar than to try to put in all the sounds preceding the conductor's down beat and be half a second late. The violins may flutter about like flags on a mainmast without much damage, but if the great double-bass, representing the keel of the vessel, is uncertain, the result is disaster.

Rests. It is a good plan to train oneself with rest studies. Count carefully when practising, not only the notes which have to be played, but the signs which enjoin silence. Rest exercises may be engaged in profitably when the student begins to tire after a spell of vigorous bowing. Take the exercises already made in various keys and substitute for certain of the notes their time equivalents in rests. Thus, if the study is in common time, and each bar contain four crotchets, arrange so as to play the first bar, keep silence during the second, when the rests must be counted carefully; play half the third bar, counting two crotchet rests to complete it; omit the first note of the fourth bar, counting a crotchet rest before playing the next three notes, and so on.

Higher Positions. Consideration of the best situation for the left hand leads up to the study of the higher shifts in double-bass playing. These go by semitones, and are reckoned by each successive new position of the first finger. After the first finger has been properly placed, the notes above are stopped consecutively by all four fingers—closed or extended as the interval is a half or whole tone—the next note being pressed by the first finger, and so on. Thus, by gliding the hand backwards and forwards on the three strings, the same sound may be produced in different ways, and changing the strings during one stroke of the bow rendered unnecessary. We give the different fingerings to show the notes that can be stopped by the same digits on the same strings [Ex. 4].

With the above key, the thoughtful student may compile exercises throughout the compass of two octaves, adjusting the fingering to enable him to take up any position instinctively.

Pizzicato. A pizzicato effect is obtainable from every variety of instrument furnished with strings, except the pianoforte. On the violin its production is often brilliant in orchestral passages. Owing to the extent of the vibrating surface, the effect of the plucked string, however, is grandest on the double-bass. When such notes occur, they are marked "pizz." To accustom the student to pulling and letting go the strings with the right hand instead of bowing them, and so obtaining the pizzicato sounds, a useful exercise is to practise four bars with the bow, four bars pizzicato, and so on.

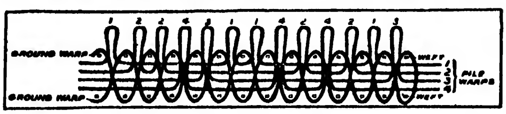
Harmonics. Of less use to the orchestral double-bass player, save for the purpose of tuning, is the production of harmonics. Yet these are obtainable with greater facility than on instruments with shorter strings. By touching lightly the strings of the double-bass at their different acoustical nodes, the series of overtones can be extended in a manner impossible on the violin. For solo playing these sounds are very effective, the so-called flageolet, or harp tones being exceptionally beautiful. Nevertheless, the function of the double-bass in the orchestra is to sustain or mark the pedal or fundamental notes, whilst other instruments supply the overtones to those fundamentals. For that reason, despite the extensive compass of the double-bass, composers do not write for it above G, an octave over the open note of the first string.

Ex. 4.

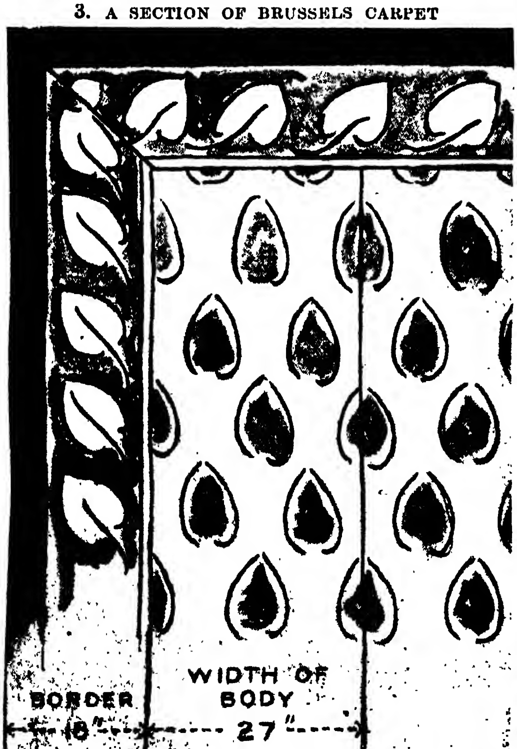
HOW A BRUSSELS CARPET IS DESIGNED

1. A ROUGH DRAWING OF THE IDEA

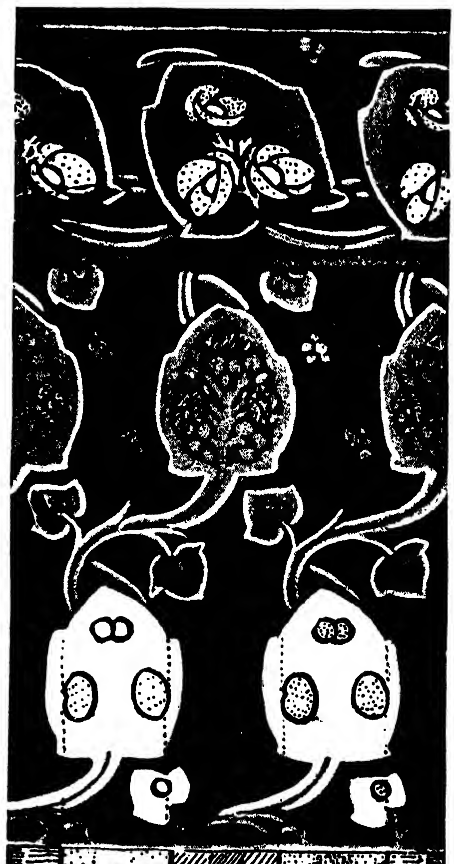
2. THE DRAWING PUT ON RULED PAPER



3. A SECTION OF BRUSSELS CARPET



4. THE METHOD OF MAKING UP THE COMPLETE AXMINSTER, BRUSSELS, AND WILTON CARPET



1 2 3 4 1

5. THE METHOD OF PLANTING FILLING

The Distinctive Features of Brussels, Wilton, and Axminster Carpets. The Manufacture of Tapestry Carpets. The Formation and Uses of Felt.

CARPETS AND FELT

CARPETS

The costliest of carpets are those made by the simplest of means. The value of labour prevents hand-making from becoming a large business in this country, although some of the finest hand-made rugs and carpets are produced here. The craft is carried on chiefly in the countries of the East, with the traditional implements of the trade.

The essentials of the work are two horizontal beams, the upper to carry the wound-up warp threads, the lower to stretch the warp and serve as a roller for the woven carpet. The weavers sit side by side in face of the vertical warp threads, each in charge of her own section. A numbered plan is at hand to show how the tufts in each row are to be placed to make the design, and each weaver has a supply of the coloured yarns, cut up into two-inch lengths. The design [1 and 2] is built up, one row at a time, by passing the tufts around each of two warp threads. The row being complete, a thread of weft is passed through the *shed* between the front and back halves of the warp. Another shed is formed by pulling the back threads to the front and the insertion of a second pick of weft completes the locking into place of the tufts. The weft is beaten home with a comb, and another row is begun.

Hand-made carpets are valued in part according to their *pitch* or fineness, which is measured by the number of separate tufts in a square inch, and the pitch rises from the nine or sixteen of coarse carpets up to the 100 to 400 of the finest makes. Woollen yarn is ordinarily used to make the tufts, and in some cases silk. The warp and weft threads are concealed and are made of any suitably strong and fine yarn.

Brussels. Machine-made carpets may be distinguished as such as have patterns produced with the jacquard, or by printing, and those that are machine-tufted in imitation of handwork. Although not now the most popular carpets, the Brussels types are the best in point of wear and cleanliness. They are seen to consist of a rough, strong backing and of an upright pile of worsted loops uniform in height and with a pattern formed entirely by the changes of colour [3]. They are woven three-quarters (27 ins.) wide, and they are sold often as four or five *frame*, denoting the number of frames or creels used to hold the bobbins supplying the yarn for the coloured pile warp.

Their quality varies with the materials employed, with the *pitch* or number of warp threads in the width of the fabric, and the number of rows of loops in one inch. In the best Brussels qualities there are about 100 loops to the square inch, for the fabric is woven with 264 worsted threads in 27 inches of width and with ten *wires* to the inch of length. Lower qualities are made down to about 36 loops to the square inch. The number of colours present bears a relation to the number of frames used, but there may be more than four colours present in a four-frame carpet, because by *planting*, or substituting threads here and there, extra shades can be introduced into the design [4]. The general effect of a design can often be improved by *planting* a few threads of another shade of the same colour; and when the shades do not differ widely from each other this can be done without employing an extra frame, by arranging carefully the order of the lighter and darker shades in one and the same frame. In four-frame goods there are, however, always four worsted threads working over each other.

Such worsted threads as are not required for the pattern rest hidden in the body of the fabric, and are raised at their proper places by the action of the jacquard. The loops are formed over wires which are automatically inserted and withdrawn upon the loom. The jacquard in Brussels weaving lifts the worsted pile threads, but the loom has an independent set of tappets and heald shafts to control the formation of the backing. Another warp, called the *small chain*, and made of cotton, is used in addition to that which forms the face, to preserve the strength of the carpet lengthwise and to bind the loops. There are two warps and two wefts in Brussels carpets, both wefts being made usually of jute. The heavier of the two, known as the *stuffing* weft, adds weight and substance and the lighter lends firmness and strength. These wefts are stiffened with glue before weaving, and the whole back of the carpet is further stiffened in course of finishing [5].

Wilton. Wilton carpets are in essentials the same as Brussels, the difference being that they are woven over flattened wires, which create a longer loop, and the loops are cut at the top as the wire is withdrawn from the loom. Each row of loops in Brussels and some Wilton carpets is secured by two shots of the weft, but in the better Wiltons every row of cut pile is held in place by three rows of weft.

Tapestry and Velvet. Tapestry carpets imitate Brussels in having a worsted loop pile, but differ in having one pile-warp parti-coloured along its length to create a design when woven. The worsted threads requisite to form the pile are first carefully printed according to a predetermined order. After being scoured, stoved in sulphur to bleach, steeped, dried, and wound on bobbins, the yarn is wound around the circumference of a large printing drum. In face of the drum are colour boxes charged with colour paste, and this is laid on to the yarn by rollers revolving in the paste. The operation requires great care, and it is conducted with the aid of a plan showing how each thread of the pile-warp needs to be coloured at the several divisions of the drum. About three inches of yarn has to be printed for every one inch of woven pile, so that the colour plan is an elongation of the original. When printed, the surplus colour is scraped away, the yarn is stripped from the drum, and placed for half an hour in a pressure steam-chest for the purpose of fixing the colour upon the fibre. The threads are then wound and set in their order, preparatory to beaming and weaving. Everything has to be so arranged that the colours will come up exactly in their right place in the

design. It is, of course, possible to print patterns upon the woven cloth instead of upon the unwoven yarn, but the result is inferior.

Tapestry is cheaper than Brussels and its structure is less complex. Against the two warps and two wefts and the several pile warps of the Brussels, there are in Tapestry only one warp (woven usually two threads at one time) and one jute weft (also woven two or three threads at once) with the worsted pile warp. Tapestry carpets are produced largely for export, and are made both in 27 inch widths and in seamless squares with dimensions of several yards. When the loops of Tapestry are cut the fabric is known as Velvet carpet. Thus Velvet is to Tapestry as Wilton to Brussels.

Art Squares. The class of carpets without pile or tufts, and sold principally for bedrooms under the name of Art Squares, Scotch, or Kidderminster carpets, is of many qualities. The figures are produced by jacquard weaving, and the thickness of the fabric is got in part by the use of stuffing threads carried between the face and the back of the square.

Royal Axminster. Axminster carpets are of two kinds, neither of which requires jacquards in weaving, so that they present great freedom in colouring and designing. The kinds known as Royal, Imperial, or Crompton Axminster are woven with two or three warps to form the base and stuffing, and with one or two wefts in addition to the tufts or *fur*. The Crompton loom upon which these goods are principally made carries a large overhead apparatus for presenting to the cloth, at the moment at which the shed is being formed, lengths of yarn to make the row of tufts. The tufting yarns are wound side by side upon spools, each spool carrying as many ends of yarn as there are tufts in one width, and the entire machine carrying as many spools as there are rows in the repeat of the pattern. Each spool, or roller, fitted with a set of tubes for conveying the yarn is set in the links of a chain and brought in turn into touch with the cloth. A length of the yarn is caught in the fabric, the end is automatically cut, and the fringe of fur is bound in position by one or two shots of weft [7].

Chenille Axminster. Chenille Axminster is made upon a radically different principle, involving two distinct weaving operations [6]. In the first place, a fabric is woven in order that it may be cut into strips of fringe and the fur or *caterpillar* thus produced is woven into the carpet to form the tufts. Chenille is woven upon the gauze principle, to which some notice has already been given. A linen or cotton warp, with its threads spaced wide apart, is put into an ordinary loom fitted with a *doup* heddle, and woollen weft of different colours is woven in rows across the warp, in accordance with a colour plan at the weaver's elbow [2]. By the action of the doup heddle alternate warp threads are drawn out of line sideways beneath their companion threads, and when crossed are lifted above them and have a pick of weft inserted in the shed so formed. The firm hold thus obtained upon the weft is seen to be of importance when the cloth is cut. The cutting is done lengthwise, and midway between the spaced threads of warp, and the colours in the fringe form the coloured pattern of the finished Chenille Axminster carpet. The fringe is heated by being wrapped round a steam-heated drum and folded so that the tufts lie on one side of the binding thread. The caterpillar constitutes an extra weft, which is secured to the backing fabric by a couple of shots of binding weft to each row. An important advantage of the chenille process is the facility with which large seamless squares can be woven upon broad looms. Cheap chenille carpets are not always equal in wear to the tuft Axminster, but they meet a large demand and are made in styles to suit every taste.

FELT

Not all the fabrics that are felted in the course of their manufacture can be described as true felts. Felting is an incidental action in a great deal of woollen cloth-finishing, and in the presence of favourable conditions most qualities of wool will *felt* or interlock their fibres one upon another. The wools most disposed to felt are those with numerous scales upon their surface and of a natural curliness. The felting action of wool can often be seen on the soles of stockings and in knitted undergarments, and especially in such as are not fully rinsed free of soap in washing. Given a combination of alkali, warmth, moisture, and pressure, the wool fibres tend to creep upon each other and to become solidly matted. The effect occurs in fabrics that have been spun and woven, but in a true felt spinning and weaving are dispensed with.

Forming Felt. Wools intended for the manufacture of felt are mixed or blended together in a heap, and they are passed through the same course of preparation as those intended to be spun [see page 2349] upon the mule. They are opened and shaken in the *willeying* machine to disentangle the fibres, open out *cots* or matted portions of fleece, and to get rid of most of their dust. The extent to which they are treated upon further opening machinery depends in part upon their condition and also upon the fineness of the quality of felt to be made. The material passes to the carding engines, which, as we have already seen, convert the wool into a thin network or film of crossed fibres. This web of fibre is drawn off at full width, and layer upon layer of the carded wool is imposed one on top of another on a lattice or table until there is a mass some sixty yards long and several inches in thickness. The *batt* thus formed is hardened by machines of which there are two general types. In one the batt passes between a long succession of steam-heated rollers, which have a reciprocating as well as a rotary movement. In the alternative type the batt is pressed by a heavy iron plate on the surface of a steam-heated table, and this plate is given a lateral as well as a longitudinal motion. The effect is to produce a fabric sufficiently compacted to bear handling and soaping and treatment in a *fulling* machine, which delivers hammer-like blows in regular succession and causes active felting to take place between neighbouring fibres. The movement of the fibres involves a considerable reduction in length and width, and, carried on long enough, it produces a dense and solid fabric that can with difficulty be picked to pieces.

Kinds of Felt. In making some felts a woven or knitted fabric is interposed in the middle of the batt, and the loose fibre is felted to its front and back. This system is used in making some underlays for carpets with a view to the prevention of stretching in wear—a result that is all the more likely to follow when, for the sake of cheapness, the wool has been mixed with jute waste and other coarse vegetable fibre. The range of qualities of felt is as wide as that of textiles of other kinds, ranging from the exceedingly fine felts used for some tablecloths down to the coarse kinds for roofing.

J. A. HUNTER

6. HAND LOOM FOR CHENILLE WEAVING

7. WEAVING THE PATENT AXMINSTER CARPET

The photographs are by courtesy of Messrs. Jas. Templeton & Co., Glasgow

Wave Action and Its Results. Organic Life in Geology. Strata. Sedimentary Rocks and Their Formation. The Origin of Fossils. Ancient Sea-beds.

GEOLOGICAL WORK OF THE SEA

The geological function of the sea is twofold. In the first place it acts as a very powerful erosive agency in attacking the coast-lines of the various continents and islands which it washes. In the second place, all great accumulations of water, both inland lakes and the ocean, act as receiving stations for the vast accumulations of detritus, which we have seen to be scraped off the surface of the land by rain and wind, rivers and glaciers, and cause this detritus to be laid down in successive layers, or strata, which have given birth to almost the whole of the sedimentary rocks. We shall first consider the *erosive action* of the sea. We all know that the sea is constantly in movement. The gravitational influence of the sun and moon cause its waters to oscillate in tides [see GEOGRAPHY and ASTRONOMY], which vary in rise and fall from a few inches in enclosed seas, like the Mediterranean, to 60 or 70 feet in confined spaces, like the Bay of Fundy. This rise and fall of the tide plays an important part in the erosive action of the sea.

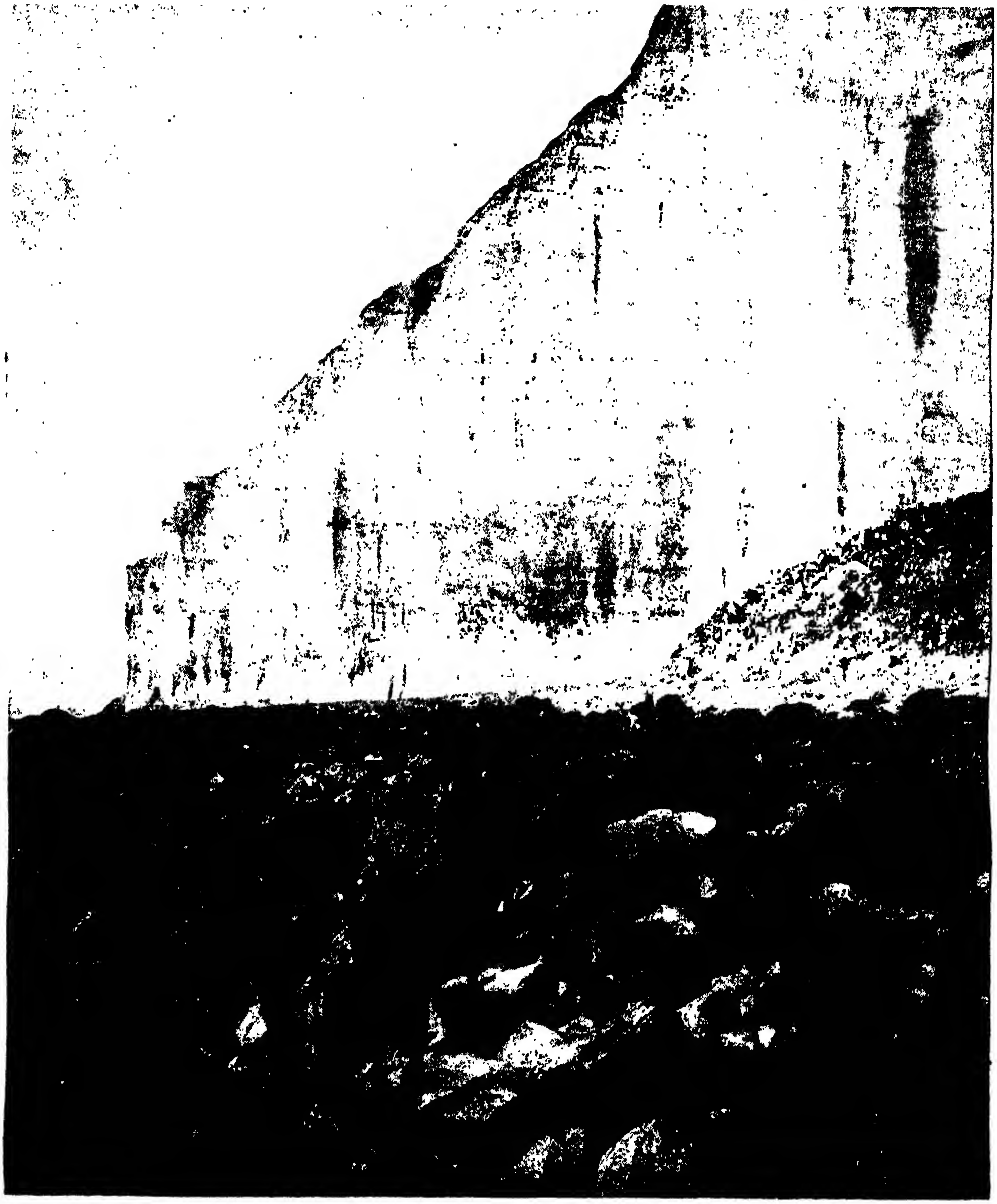
Tidal Action. Where, as on the British coast, there is a normal difference of 10 or 20 ft. between high and low water, the actual rise and fall of the water has a disintegrating effect upon the coast-line. The space between high and low water-marks is generally occupied by a beach consisting of shingle, sand, or mud, which are all alike the disintegration products of the rocks which line the coast. Tidal movement alone tends to widen this beach and make it slope more gradually out to sea. Where the coast is bounded by precipices of hard rock, like granite, the beach may be altogether absent, and the water simply rises and falls against the cliff.

Erosion by the Waves. The chief disintegrating agency of the sea, however, consists in its waves, which are caused by the friction of the wind upon the water. These waves exert tremendous force when they strike upon the cliffs and beaches. In some cases on the coast of Scotland they have been known to exert a pressure of three or four tons on the square foot. The enormous force of these breakers tears off fragments from the solid rock, often many tons in weight, and washes them about like pebbles. These fragments are often launched against the coast-line by the returning wave, and serve as battering rams to increase the destruction [59]. As a rule the sea-cliffs are not a solid wall, but are penetrated in all directions by *joints* or *fissures*, which help the disintegrating action of the sea, just as in other cases they simplify the labours of the quarryman. The pressure of the onrushing waves and the air which they drive into all these cracks and crevices gradually enlarges the fissures and joints of the rock, until huge pieces come tumbling down into the sea, where they are washed about and ground together until they are ultimately broken up into mere gravel and sand. The vast accumulations of sand that form the ordinary sea-beach are all formed of quartz, one of the hardest of rocks, which has thus been broken down into mere dust.

The actual rate at which the sea carves away the coast-line depends, of course, upon the hardness and structure of the rocks on which it breaks. Granite precipices like those of Peterhead scarcely change perceptibly in the course of a century, though the bold and picturesque features which they present are wholly due to the progress of marine erosion. The striking cliffs of the Cornish sea-board illustrate every stage in the process. Where the coast is composed of comparatively soft rocks, as on the sea-board of East Anglia between the Wash and the mouth of the Thames, the sea eats rapidly into the land; in some places four of five yards per annum are said to be washed away, and the erosion of our East Coast at places like Southwold has become a very serious problem to the engineer as well as to the geologist.

Marine Transport. The sea also performs the work of transport, carrying much of the sediment derived from this erosive process considerable distances. We deal with this part of its action later, when we come to consider the construction of sedimentary rocks. It is enough to note here that, in addition to the ordinary transport of sediment by oceanic currents, a considerable quantity of rough and rocky fragments is carried out to sea by the icebergs which break off from the vast glaciers of polar regions, and travel southward until they ultimately melt and drop their moraine-stuff on to the sea-bed.

Geological Effects of Life. The last agency which we have to consider as helping to break up rocks and rearrange their materials is that of life. Both *plants* and *animals* have played an important part in the superficial moulding of the earth. Their work is both destructive and reproductive—the latter being more important from a geological point of view. The destructive action of plants is necessarily confined to the superficial layers of the soil, since they can only live in places where they can obtain air and sunlight. The effect of their roots penetrating through the soil and wedging apart the joints of the rocks is often very marked, as when the growth of a tiny plant is found to have lifted paving-stones out of their proper position. The disintegrating effect of plants on the soil, however, is more largely due to the *chemical products* of their decay, which frequently attack various rocks, dissolving or changing their substance.



59. THE GRADUAL DESTRUCTION OF BEACHY HEAD BY THE SEA

Animals and their Geological Work. The influence of animals on the soil is not very important, except in the case of the common earthworm, which Darwin proved to be an extremely diligent fertilising agent. These worms spend their lives in bringing up the deeper particles of soil to the surface, and thus play an important part in the operations of agriculture. Other animals, like the beaver, modify the geological developments of the district by interfering with the course of streams. Some mulluscs riddle a considerable number of rocks with holes, which promote the work of disintegration by rain or sea-water. Of course, it is hardly necessary to add that man, in his various civil engineering operations, sometimes becomes a powerful geological agency.

Rocks Due to Organic Agencies. The *reproductive* action of life upon the earth is extremely important—at any rate, from the human point of view. The *coal measures*, or strata of carboniferous rocks on whose exploitation the modern development of industry has been built, are entirely the product of primeval vegetation which has decayed and been buried

for long ages, to yield up its carbon at last for the use of man, who warms his house and drives his engines by unlocking the energy which these old-world plants once derived from the sunlight.

Soils. The fertility of our richest soils, such as the loam of the American prairies and the black earth of Russia, is due mainly to the long continued growth and decay of the vegetation which has given up its organic residue to mix with the mineral debris, and so form the best kind of soil for agriculture. The well-known Tripoli powder which is used for polishing, mainly consists of the debris of diatoms of tiny plants which have the knack of extracting silica from sea-water and weaving it into their fabric, whence it ultimately accumulates in beds on the sea-bottom The production of some important metallic ores, such as bog iron ore, is largely due to the agency of vegetation.

Coral and Chalk. Some important rocky formations are due to animal life. Great masses of limestone are derived from the shells of tiny marine organisms which have accumulated on ancient sea bottoms. Coral reefs [see page 426], which are chiefly composed of carbonate of lime, are entirely built up by the animals known as corals, aided—as we saw in an earlier section—by the slow subsidence or upheaval of the land.

There are great masses of limestone found in the Alps and Pyrenees which were originally deposited as coral reefs in the warm prehistoric seas which once rolled over the sides of these mountains. The great beds of chalk, again, which form so large a portion of southern England, and furnish that most characteristic and beautiful of spectacles, the white cliffs. which look like frosted silver when one gazes at them from the other side of the Channel, consist

60. STRATA SHOWING DIP AND OUTCROP

almost entirely of the tiny shells and skeletons of minute organisms which once lived in the sea, and rained down these tiny shells and skeletons on the sea-bed as they died in countless numbers.

FORMATION OF THE STRATA

We have seen thus far how many agents are at work to wear down the surface of the earth, and disintegrate the primitive rocks. These processes have been at work since the earliest and unrecorded beginning of things. No sooner had the crust of the earth solidified than the agencies of denudation and disintegration began to operate upon the bare and cindery surface of the igneous rocks. At first these agencies were less powerful than they became after the water had liquefied and the action of rivers and seas was added to that of atmospheric influence. But they have ever been at work, abrading the original rocks and wearing them into sand and debris. We have now to see how this loose material was again formed into new rocks, of which the greater part of the earth's surface is now composed.

61. THE FORMATION OF STRATA

S S. Planes of stratification. C C. Planes of cleavage. J J. Joints

As we have seen, the chief influence in the work of denudation and disintegration was running water. But water cannot run down hill for ever ; sooner or later it must sink to a level beyond which it can go no lower, and therefore ceases to move. The bodies of water which represent this lower limit of stagnation are known as *lakes* or *seas*.

Lakes. Lakes are bodies of water occupying depressions on the surface of the land. They may be either fresh or salt. It will usually be found that a fresh-water lake has an outlet for a great part of its waters in the shape of a river. When there is no such outlet and the water brought in by rivers is able to escape only by means of evaporation, the lake inevitably becomes salt, because the rivers are always bringing in a certain amount of dissolved material which is unable to escape, and the chief constituent of this material is common salt—the most readily soluble of all minerals. As the volume of water in a lake usually remains fairly constant, but the quantity of salt is thus being steadily increased, the lake must get salter and salter until its water reaches what is known as the *saturation point*, after which the water can hold no more salt in solution, and for every pound of salt brought into the lake a pound is crystallised out on the shores of the lake.

Seas. What we call seas or oceans are simply vaster lakes which occupy the gigantic depressions which were formed on the surface of the earth by ancient geological agencies. We do not quite know how these depressions were formed. Some of them are probably due to a general subsidence of the land. This is certainly the case, for instance, with the basin of the Mediterranean. There is a possible theory that the vast Pacific Ocean occupies the scar which was left when the huge bulk of the moon split off from the earth, as has been explained in an earlier section. But though the seas and oceans are incomparably larger than any of the

bodies which we call lakes, there is no essential difference between the two. We may speak of the great lakes of North America as inland seas, or of the seas as vast salt lakes. A distinction is usually drawn by geologists between sedimentary rocks which have been deposited in a lake or in the sea, but there is no essential difference.

How Sedimentary Rocks were Formed. It is on the beds of these sheets of water that by far the greater part of the sedimentary rocks have been deposited. It is not difficult now to see how this has happened. We have already seen that every river brings down a considerable body of sediment—fine sand or mud, the débris of the rocks which have suffered disintegration under the various erosive agencies. The greater part of this sediment naturally remains suspended in the water by virtue of its motion. When the water ceases to flow, the sediment gradually sinks to the bottom. This process is illustrated by the familiar experiment of stirring up a bowl full of pea soup, which essentially consists of water containing a greater or smaller quantity of organic sediment—meat fibre and the like. After a thorough stirring the whole of the soup is turbid and fairly homogeneous. But if it be allowed to come to rest and stand for a time a great deal of sediment settles down to the bottom and leaves on the surface a comparatively clear liquid. Exactly the same process is involved in the common injunction to shake a bottle of medicine before pouring out a dose.

Deposit. When a river runs into a lake or the sea, it gradually loses its motion and comes to rest, though, in the case of great rivers like the Amazon or Mississippi, the current may still continue to move for many miles out to sea. As it slows down it steadily deposits its sediment on the bed of the lake or sea. The same thing happens along the bed of the river itself; whenever it passes into a quiet pool and suffers a temporary loss of speed, the sediment is thus deposited with fair equality in all directions. As time goes on the deposit becomes thicker and thicker, until, if there be no disturbing influence, a great part of the lake may be silted up by these deposits, through which the river goes on its way and keeps merely its own channel open. It is thus that *bars* and *sandbanks* are formed at the mouths of many rivers, and that *deltas* are constructed, stretching in numerous instances far and wide out into the sea.

The Process Discontinuous. As a rule, the process of deposition is not continuous. On the one hand, few rivers run with an absolutely steady current. At one season of the year, when their waters have been fed by excessive rainfall, they come down bank-full with a rapid current thickly charged with sediments of all kinds. At other seasons, when rain is scanty, the volume of the current may be greatly diminished and trickles into the lake or sea almost devoid of sediment. Again, the recipient body of water may at one time be calm and ready to receive the sediment evenly on its bed; at another time it is convulsed by storms, and the sediment is thrown far and wide and heaped up in irregular accumulations instead of being spread in a homogeneous sheet. It must further be noted that when the deposits thus brought down by rivers become of considerable thickness, their lower portions are subjected to the pressure of the upper ones, which may in time amount to several tons per square inch. In this way the lower portions of the sediment are compressed and hardened into a more or less solid rock, just as powdered graphite and other substances can be made into solid blocks in a hydraulic press.

The Strata. We are now in a position to see why it is that the sedimentary rocks are almost always found to be arranged in *layers*, *beds*, or *strata* [60]. If the process of deposition were absolutely uniform we should expect to find the sandstones and shales, which are simply hardened deposits of sand or mud, showing no signs of *bedding* or *stratification*. But it is almost always found that the processes of Nature are not continuous, but work by fits and starts. This is generally the case with the deposit of sediment by water. Take the case of the ordinary river; when its current is full and swift, it brings down a great mass of sediment, which is deposited on the bed of the lake or sea into which it flows; then, with the change of seasons, comes a period during which little or no sediment is deposited. By the time that the rains again set in and the abundant deposit of sediment begins once more, the lower portion has settled down and formed itself into a roughly horizontal layer, with a well-defined surface and a slight beginning of hardening on the surface under the pressure of the water. The next accumulation of sediment is spread over this and passes through the same process; there is usually a well-defined surface of demarcation between the older and the newer layers. This process is constantly repeated throughout long geological ages, and thus the rock which is finally formed on the bed of the sea or lake is found to be divided by planes of stratification or bedding [61], which are generally more or less horizontal and parallel to one another. Their thickness will be greater or less, according to the amount of sediment brought down each time the river is in flood, and to the relative intervals which elapsed between the arrival of fresh deposits.

The Origin of Fossils. Of course, the process of forming a sedimentary rock is here reduced to its simplest elements, and a great deal of modifying detail has been omitted. We may note, for instance, that a great deal of extraneous matter will be mingled with sand or mud brought down by the river. The organisms which lived in the water are constantly dying, and their remains settle down upon the floor of the lake or sea, and are there buried under the steady accumulation of sediment. This is the origin of the majority of *fossils*, which are so continually found in sedimentary rocks. The soft parts of the organisms decay, but they may leave their mould in the hardening sand or mud, which is often filled in and preserved for future

ages by some mineral which the water holds in solution. Then the harder portions, such as bones, teeth, or shells, may be preserved almost unchanged, and it is the existence of such relics of long extinct species that enables us to form sound theories as to the gradual evolution of life.

Fossil Vegetation. Vegetation that has been swept into a lake or sea often becomes water-logged, and sinks to the bottom, there to leave its impress upon the growing rocks. A considerable part of the coal measures consists of vegetable matter, which was thus accumulated under water and buried by sedimentary accumulations.

It will thus be seen that the sedimentary rocks have mostly been formed near the shores of lakes or seas. Evidence of this is afforded by the fact that a large number of sandstones and shales bear proof of having been alternately covered and deserted by the sea as they were being formed. The sea-beach between high and low water-marks is simply a sedimentary rock in process of deposition. As the tide ebbs and flows it is alternately exposed to the air and dried by the sun, and then buried under the waves. As a rule, any markings which are made upon it by the rain, the footsteps of animals, or the elementary sculptures of the human child, are washed out by the return of the sea. But sometimes these marks have been preserved.

62. SANDSTONE, WITH FOSSIL FOOTPRINTS OF THE LABYRINTHODON, AN EXTINCT REPTILE

Footprints on the Sands of Ancient Seas. Where a beach is composed of mud rather than sand, its surface may dry so hard in the sun that any marks thus left upon it are retained [62] until a new layer of sediment is deposited upon them, and thus they are preserved to interest geologists of a future age. Many shales and other mud rocks when split open are found thus marked with the footprints of prehistoric animals, or pitted with the raindrops and sun-cracks of days that knew not man. If we take these markings in conjunction with the fossil remains that are found in the same rocks, and which all belong to creatures living in shallow water or between the limits of high and low tide, it is quite clear that such rocks were laid down at the edge of an ancient sea-beach. It is thus possible to trace the limits of long-forgotten seas and oceans, and to make maps of the distribution of land and ocean at various periods in the history of the earth, from which we see that the existing arrangement of the surface in this respect is quite recent.

British Geological History. Thus, to take a few examples from our own island record, we know that in the earliest Primary age the greater part of our islands was under the sea, but not far from a continent, whose rivers washed down the sand and mud which composed the slaty beds of Wales. The rocks on the top of Snowdon consist of volcanic ashes which were deposited on the floor of this shallow sea. In a later Devonian age, reef-building corals were at work in the warm seas which must then have covered the south-western parts of our islands. Their record is found in the limestones of Devonshire. The old red sandstone points to a period in which a great part of our islands was dry land, intersected by numerous arms of the sea, or perhaps covered by vast fresh-water lakes, on whose beds these rocks, so rich in fossils, were deposited. The great coalfields which have made our country so prosperous indicate that there was a time when semi-tropical vegetation covered great parts of the land, which must then, of course, have been raised again above the sea, into which it subsided once more in order to allow of the deposit of the sandstone which overlies the coal measures in so many places.

A British Sahara. The New Red Sandstone is thought to have been laid down under desert conditions, when our country formed part of a vast continent with a warm and extremely dry climate—not unlike that which now obtains in the Desert of Gobi or the Sahara. We can almost watch the gradual irrigation of this arid region by natural processes, and the appearance here and there of lakes, each of which has left its traces in deposits of gypsum and of rock salt. Once again the British area was submerged beneath the Jurassic seas, inhabited by strange fishy forms, whose beds were covered with sediment almost as fast as they continued to sink, so that many thousands of feet of sediment were coagulated into rock, and the seas remained comparatively shallow. The great chalk deposits, again, point to yet another age of submersion, followed by an Eocene period in which our country was occupied once more by land animals. Another continental period followed, and then came the ice age, on the very threshold of modern times. All this history, with much more that will be found detailed in the works on the subject, is deeply engraved on the rocks and written in the everlasting hills.

W. E. GARRETT FISHER

The Processes of Machine Moulding. Various Moulding Machines. Wheel Moulding. Construction and Use of Moulding Boxes. Weights of Castings.

MACHINE MOULDING

The highest development of moulding, that by machine, is one that grows very rapidly. It is divisible under two groups—one devoted to general work, the other specially to toothed wheels, the latter constituting a very much smaller group than the former.

Types of Moulding Machines. In reference to the first, there are some dozens of distinct types of moulding machines now made, and operated either by hand, as in **98** and **99**, steam, water, or compressed air. Patterns may be rammed by the machine, or by hand, but they are always withdrawn under the control of the machine slides. In the clean delivery thus obtained much of their value lies. In England and Germany a large amount of hand ramming is adopted in machine moulding. In the States ramming is more often done by mechanical means. There would be no special difficulty in compressing sand by mechanical means over a perfectly level surface; but the surfaces of patterns are seldom level, but of more or less irregular contours, and the difficulty of mechanically ramming uneven surfaces is that the sand inevitably becomes harder and softer in different localities. It is therefore necessary to prepare special pressing plates in such cases, corresponding at least approximately with the contours of the patterns to be pressed. As the cost of these can be incurred only when a considerable number of similar moulds are required, this helps to explain why hand ramming is preferred in the majority of cases.

The patterns moulded in machines are attached to a plate—or often cast solidly with a plate—the opposite faces of which provide the faces upon which the mould joints are rammed directly, so saving the trouble and time of making sand joints. And again, it is usual, when possible, to mount several small patterns on one plate to increase the output per mould.

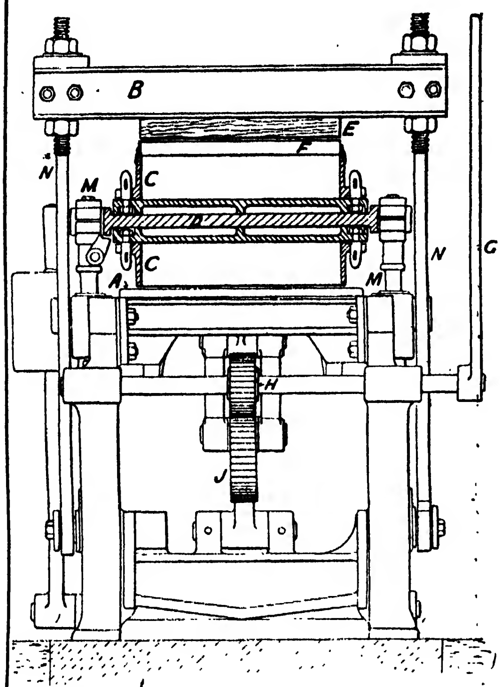
We can better understand the general methods of machine moulding if we consider in brief those methods which lead up to it, and of which it is the complete development. These are bottom or joint boards or turn-over boards, and plate moulding.

Bottom Boards. Turn-over boards, bottom boards, or joint boards, as they are variously termed, are used to save the trouble of making the sand joints each time the pattern is rammed up, or else to sustain a flimsy pattern, or to fulfil both functions at once. Different forms of turn-over boards are made to suit requirements. Perfectly flat boards are used for any flat-jointed patterns, and kept in foundries in different sizes to suit moulding boxes of various dimensions, the pins passing either through holes in the board, or beside its edge. Any flat patterns, jointed or unjointed, may be laid upon these to keep them straight while being rammed up, as pipes, columns, cylinders, thin plates, and such like. Fig. **103** shows such a board (A) maintained truly with battens. It is not quite the simplest bottom-board arrangement, because instead of a complete pattern being used, a set of half patterns is shown, and there will be another board with half patterns exactly like this for the bottom box. A halfway stage between this and the absolutely plain board is the board of the brass moulder, cut out to drop unjointed patterns into. In this, those handwheel patterns would then be complete, but solid, and sunk into the board to their central planes. Then one half box would be rammed over them, and turned over, and the board taken away, leaving the other half of the patterns exposed to be rammed. In **103**, however, there are two sets of half patterns on different plates, and no turning over is done. In this figure, note may be made of the way in which the box is confined by the corner blocks, of the runners radiating from the central ingate, and of the lifters hanging from the bars. In the upper or plan view, the bars are broken away to show the pattern arrangements clearly.

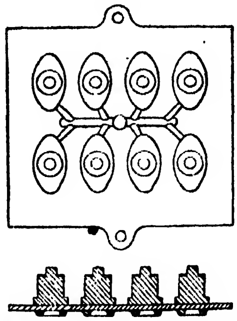
In another stage, if irregularly-shaped sand joints are required, blocks are put on the board, of shapes corresponding with the sand joints. Plate moulding in its simplest form is embodied in these arrangements.

Metal Plates. Figs. **100** and **101** show a more advanced stage. Here the plates are of iron, and the patterns are of iron or of brass, and attached to opposite sides of the plates, so that if the plate thickness were removed, the pattern portions would make up a complete pattern. In each case, sprays of runners are screwed or riveted to the plates. Fig. **102** illustrates pattern parts and plate cast together, a method adopted when the work is standardised, and in constant service from year to year.

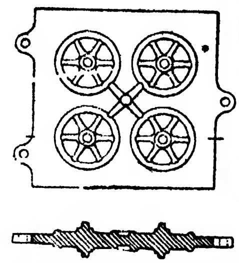
Advantages of Plate Moulding. It should be obvious that this system of plate moulding is vastly more economical and accurate than hand moulding when much repetition work has to be done. Its employment does not necessarily involve the use of a moulding machine, since there is a large amount of work of this kind done without the aid of the latter, the machine being mainly a mechanical aid to facilitate the better delivery of the pattern. Plate moulding is an extension of the use of the turn-over boards; but in the case of such boards, the pattern, either in whole or in halves, is made distinct from the board, and in the



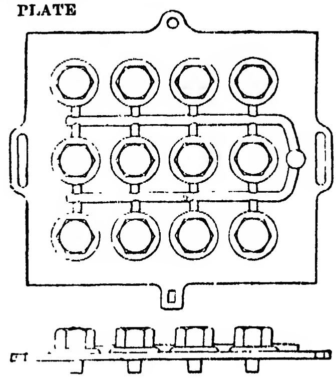
98. MOULDING MACHINE (FRONT ELEVATION)



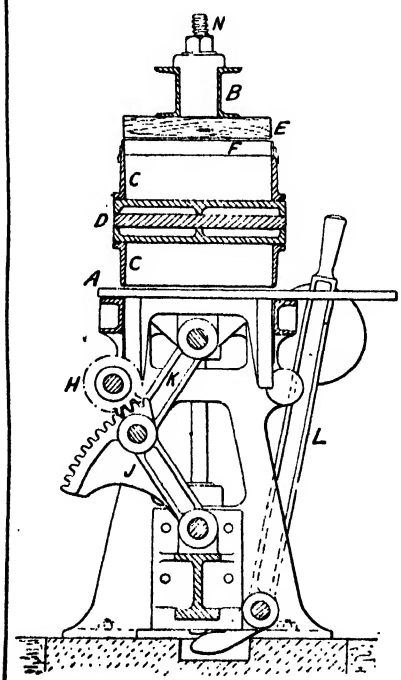
100. GLAND PATTERNS ATTACHED TO A METAL PLATE



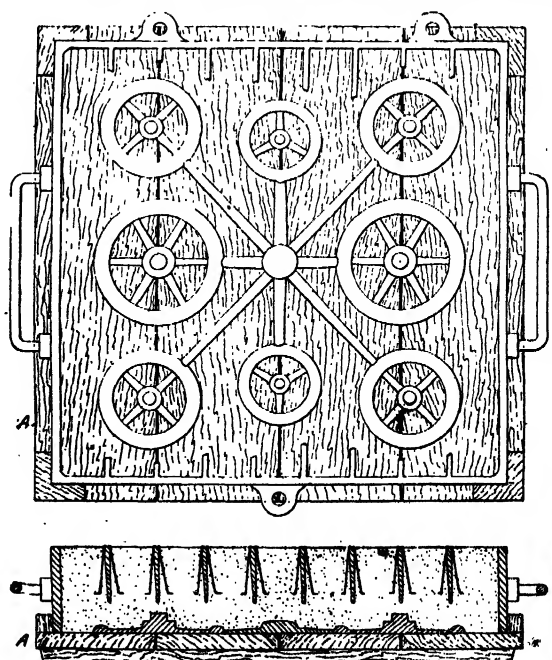
102. HALVES OF HAND-WHEEL PATTERNS, CAST WITH THEIR PLATE



101. NUT PATTERNS ATTACHED TO A METAL PLATE



99. MOULDING MACHINE (SIDE ELEVATION)



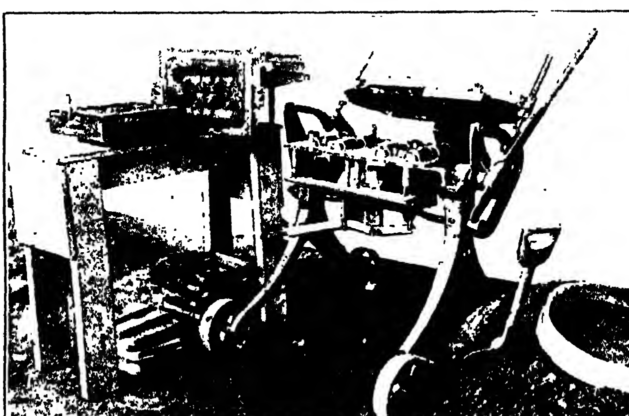
103. BOTTOM BOARD, WITH HALF PATTERNS AND RUNNERS ENCLOSED BY MOULDING-BOX

98–103. MOULDING MACHINE AND PLATE MOULDING

simplest case the latter merely forms the first sand joint face—namely, that of the bottom box part, upon which the top face is rammed; and the whole, or half pattern, as the case may be, remains in the bottom part, while such portion of it as comes in the top is also rammed at the same time as the top joint face. But in plate moulding [100-103] the faces of the sand joints do not come into contact until the final closing of the mould for casting, for each face is rammed against the joint board or plate, and the pattern sections which belong to top and bottom respectively are fastened to, or are integral portions of the board or plate itself. The principle is simply this: that whatever shape the pattern is, those portions into which it is divided by the plate would, if the plate were removed, differ in no wise from any ordinary pattern. The plate is therefore simply a piece interposed between those portions of the pattern which come in the top and the bottom boxes.

104.
HAND MOULDING MACHINE
(Samuelson & Co., Ltd.)

Patterns for Plate Moulding. In much work of this character, wood as a material of construction [103] is discarded altogether, and iron employed for plate and pattern [100-102], and often the whole is combined in one casting, as 102, which shows plate containing four hand wheels with their runners. A pattern is first prepared in wood, from which the plate with its lugs, runners, and pattern wheels is moulded and cast. The whole is then got up by filing, turning, or other suitable means, the amount of work bestowed upon it varying with the custom of the shop; some machining every portion, others leaving the faces rough, as cast, and only truing and smoothing the edges which draw vertically. After tooling, the pattern and plate are rusted over with sal-ammoniac and water, warmed, and well beeswaxed, to impart a smooth skin for delivery from the mould.



105. PORTABLE HAND MOULDING MACHINE
(The Adams Company)

A secondary advantage of the use of metal-plated work is that the evils which are more or less inseparable from the warping of timber are eliminated, and better, smoother surfaces are obtainable, and consequently better deliveries and smoother castings.

Moulding by Machine. If now, instead of withdrawing the pattern from the mould by hand or with a crane, which owing to its unsteadiness is a frequent cause of breaking down of the moulds, the plate be fitted on the table of a machine and the mould withdrawn from the pattern by a lever or a ram, perfectly plumb and steadily, the last risk of fracture of the mould is well-nigh eliminated, and this marks the perfection of plate moulding.

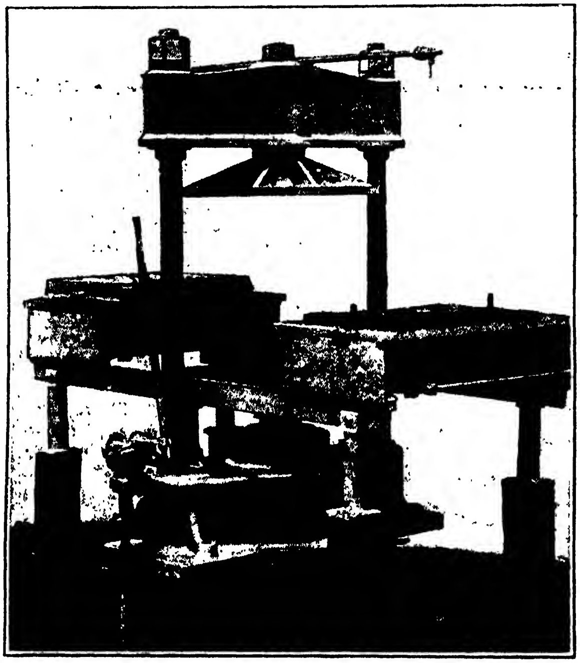
Examples of Moulding Machines. Figs. 98 and 99 illustrate in front and side elevations and part sections one type only among the many moulding machines. It is one of the most improved designs, in which the ramming, or, rather, pressing, is accomplished by power. The machine framing comprises two sides connected with horizontal stretchers. Between the table A and the crosshead B the sand is pressed into the moulding boxes, C C, which are fitted through intermediate plates with pins to the turnover table D. A presser board E attached to the crosshead pushes the sand into the box part which happens to be uppermost, the surplus sand necessary being confined by the loose frame F. The pressure is imparted by the hand lever G actuating the pinion H and toggle levers J K. The pattern and plates are lifted from the box by the counter-weighted lever L actuating the side rods M M, in the bosses of which the table can be turned over for ramming the two box parts. The crosshead B is swung aside during the filling of the boxes with loose sand, being pivoted by the rods N N.

Fig. 104 shows a plain type of machine in operation. The pressing is done by the top crossbar, pulled down by levers actuated by the long handle seen grasped by the attendant. The pair of boxes are seen between the table and the presser-bar.

In 105 we have a development of much value, the portable machine, running on wheels, so that it can be easily pushed about the foundry to any

convenient location, leaving the moulds in its wake as they are made. The half-patterns are seen on the machine table, with the presser board thrown back, while on the bench alongside are the moulds produced. Underneath the bench will be noted several of the steel bands or frames mentioned later in connection with snap flasks.

Hydraulic Moulding Machine. A hydraulic machine is illustrated in 106, consisting of a press, with ram below and crosshead above. Above the ram the boxes are carried on rails, so that they may be run back from beneath the crosshead, and the sand filled in conveniently. Then one box is pushed along to the centre, and the rise of the ram lifts the box and presses the sand against the opposition of the plate attached to the top crosshead. Lowering the ram withdraws the pattern. In addition to the power obtained by hydraulic pressure, there is the further advantage in this class of machine that as many as four men can be set to work —two filling and pressing, and two removing the boxes and placing them together.



106. HYDRAULIC MOULDING MACHINE

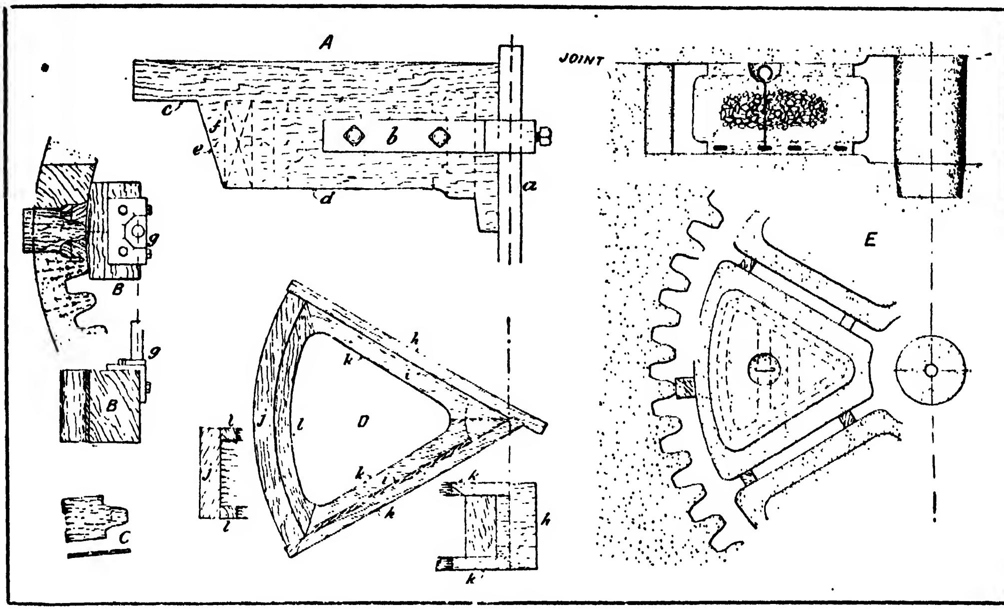
Where Machine Work Scores. The examples which have been given are comparatively plain, the better to illustrate the elements of plate and machine moulding. But the full advantages of the system are most apparent in patterns of intricate forms—that is, which involve more sleeking and shaping of joint faces, etc., on the part of the moulder, more work in cutting of runners; also patterns which are moulded in very large quantities by firms who deal in specialities, and which, being usually of small dimensions, can be and are moulded several at a time on a single plate. The highest economies are secured when patterns of small and medium dimensions are grouped on plates along with their runners, and when joint faces are not plain. Patterns which are not cored, or cored only to a small extent, are more economically moulded than those in which many intricate cores have to be fitted and properly secured. Shallow patterns, and patterns without vertical edges, deliver best, but deep patterns with vertical faces are eminently suited for plate or machine moulding when a stripping plate is employed.

Wheel Moulding. The moulding of toothed wheels by machine means that a complete pattern is not required, and that the employment of mechanism produces more accurate results in the pitching or spacing of the teeth than can be ensured by hand work with a full pattern.

The wheel moulding machine is a dividing machine, having change wheels and worm gear for the pitching, together with mechanism for operating and withdrawing the tooth block. The cores for the arms are made by the usual methods of core making, and inserted in place by hand.

The general process of wheel moulding is as follows. The moulder is provided by the patternmaker with all necessary parts, such as tooth blocks, core boxes, etc., which vary with each type of wheel—spur, bevel, worm — and with the shape of the arms, the presence or absence of shroudings, etc. We can take only the case of a plain spur wheel with a plain top. The top box is rammed distinct from the wheel mould upon a plain level bed of sand, and calls therefore for no remark. If the wheel be large and made in the floor sand, a coke bed is provided underneath, and the whole area of the wheel is vented down to this bed. Small wheels are moulded in a bottom box. In the case of the spur wheel selected [107] the bed and the top joint face are made with a striking board A. On it the half section of the wheel is marked as a guide to the moulder in setting the cores. It is attached to the striking bar *a* by a strap *b*. It strikes *c*, the top joint face, *d*, the bottom of the bed, and *e*, a wall of sand, at 2 in. or 3 in. distance away from the tooth point, leaving a space *f* for the reception of the facing sand, to be rammed within and around the tooth spaces. In bevel wheels it is better to cut the board precisely to the bevel and diameter of the tooth points.

Formation of the Teeth. The ramming of the tooth block B follows. The one shown has two teeth; but many contain three or four. The more teeth used the greater the precision demanded, because each tooth space must be an exact counterpart of its fellow. Each space has, moreover, to be rammed up with the



107. DETAILS OF WHEEL MOULDING BY MACHINE

same expenditure of labour as any other, so that the only time saved is that in elevating the block.

Having a tooth block, the spur B, shown or a bevel wheel block bolted to the carrier *g* of the machine, the radius is set by means of a strip cut to extend from the central striking bar *a* to either the root or point of the tooth, and the arm is permanently clamped in the position corresponding therewith. The block is lowered by means of the vertical slide of the machine until it touches, and just presses upon the bed struck by the board A, and the ramming up begins. The ramming must be done so that the connection between the tooth spaces and the outer body or wall of sand struck by the sloping edge of the board A shall be complete, so that there will be no risk of the narrow pillars or sections of sand in the tooth spaces becoming washed away. This union is effected by means of nails—two, three, or four being rammed in along with the sand to form a bond of union, as shown in 107 at B. Facing sand is rammed within the teeth to the thickness of about 1 in. or 1½ in., and black sand behind, and a block on one side supports the sand being rammed there.

The tooth block is lifted by the vertical arm of the machine, the sand being prevented from pulling up by holding a flat piece of wood, C, on its surface. It is then moved a distance equal to the pitch by the dividing apparatus of the machine, lowered and re-rammed, and so on, as indicated at B.

The Arms. There are many different methods of formation adopted for the arms of spur wheels. The H section type is the most common, because it is the easiest to make, and the strongest. But other forms are often adopted, either because the wheels are too small for H arms, or because that type would be out of harmony with adjacent gears; because wheels have to replace broken ones, or they have to be cast against something else which necessitates some other shape, or on account of the designer preferring an older type of arm. We can take only for discussion here the moulding of a spur wheel with H section arms.

As usually made, the core-box is of the form shown at D [107] in plan and part sections. The two sides *h h* are notched together at the angle required for the arms, 60 degrees if for six arms, 45 degrees for eight, 90 degrees for four, and the inner faces corresponding with the centres of the ribs; the thickness of ribs, *i*, is equal to half the thickness of the arms. The inside of the sweep *j* corresponds with the inside of the rim of the wheel, and the flat arms *k k* and inner ribs *l l* are divided to allow of delivery of the core. The core being rammed up, the screws which connect the sides with the sweep are withdrawn, the sweep *j* drawn away horizontally, the sides also drawn in the same manner, and the core left standing on the ramming board or bed.

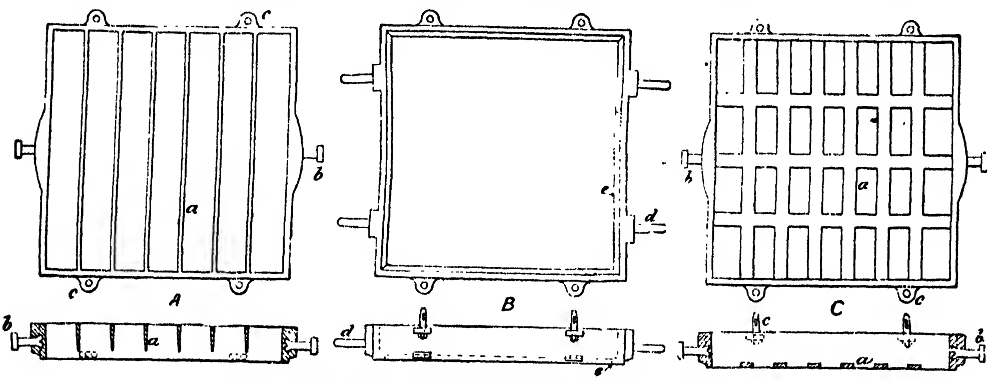
The mould is shown in section and plan [107 E] and the relations of the several parts are apparent, together with the method of gauging the thicknesses of arms and rims when setting the cores.

Boxes and Flasks for Moulds. Moulds cannot be made without boxes or flasks of some kind. There is only one exception to this—those moulds made in open sand. But these are a mere trifle in comparison with the work done in boxes. They require little skill, and are reserved chiefly for the making of the moulding boxes themselves and the

roughest class of foundry tools, as core plates, core rings, grids, lifters, and such-like. A moulding box is essentially an open-frame box for enclosing and confining the mould. It may be made of stout wood, as is sometimes the case both in iron and brass foundries, especially in America, but it is generally made of iron. Boxes are subject to great stresses, due to the hard ramming of the sand within, the pressure of molten metal, and the twisting strains due to the handling and turning over when loaded with sand and castings. For this reason they are made stout and strong.

Then, further, since the carrying of a large mass of sand by its simple friction within the sides of the box would be impossible in those of large areas, cross-bars or stays are made to reach across from side to side at intervals of a few inches. Also, since the adhesion of the sand is much assisted by rough surfaces, the boxes are purposely cast very rough, and, in fact, their inner faces and the surfaces of the bars are sometimes artificially roughened over. Then chance of tumbling down, assisted by "lifters," which are suspended from their top edges [102, page 2893]. The bottom edges of the bars are kept back a little way (¾ or 1 in.) from the joint face to give room for a stratum of sand, and the edges are chamfered to allow the ramming which takes place through the top to have full effect under the bars, which it would not do if they were square.

Boxes for Turning Over Work. In all moulds that are made by the process of *turning over*, the boxes consist of two or more parts. Boxes that are used in turned-over work are necessarily divided, and the number of their joints corresponds usually, though not invariably, with the number of joints by which the mould is divided. When a box is in two sections only, those two may be perfectly symmetrical and alike, or their bars may be of different forms and variously arranged. When a box is divided into more than two portions, the middle part or parts always differs from the top or bottom, being usually destitute of stays. In 108, while A is a



108. STANDARD BOX TYPES FOR TURNING OVER IN

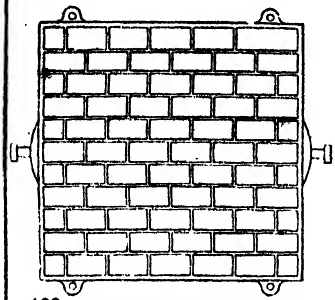
provision has to be made for uniting the box parts of a set to one another, and also for turning them over. Other provisions are made in some cases, such as flanges for back plates, holes for core-bars, for core-vents, and the like.

Forms of Boxes. The forms of boxes vary in almost every conceivable way. They are mostly rectangular, being both square and oblong. But many are circular, some polygonal and a few which are employed for special purposes of various odd shapes.

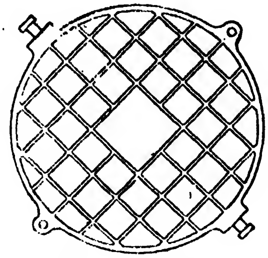
There are several conditions by which the forms of boxes used for different purposes are governed. Thus, when patterns are moulded by bedding-in, by turning over, and in middle parts, corresponding differences in the forms and fittings of the boxes are necessary. When a pattern is moulded by *bedding in*, a top box alone is used [108, A]. That is, the whole or a portion of the pattern will be rammed in the sand that forms the floor of the foundry, and its top face only, with such portions as may happen to project from that upper face, will be formed in the box.

In the figure, *a* represents the stays or bars which serve to retain the sand securely from the top, B is a middle, and C a bottom box, or drag. B is destitute of bars, C has flat ones. The section of the standard form of unsymmetrical, two-parted box is when A is placed on C. In the three-parted, B comes between A and C. The shape in plan may be square, as shown, oblong, circular, or any other special form. Observe the difference in the shape of the bars in A and C. Since the part C rests upon the floor, there is no risk of the sand falling down, as there is in the top A, where the sand is liable to fall into the mould. The bars in C are therefore simply flat, and they keep the body of the sand in the box distinct from that on the floor. But the bars in A serve to support the mass of sand above the mould. B has no bars, because they would be in the way, the centre portion of the box being occupied with the mould.

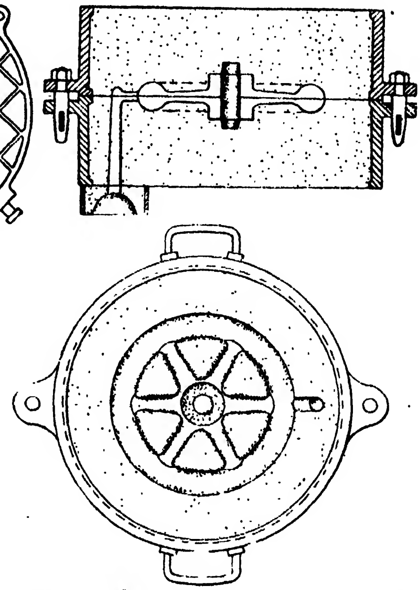
But as it is necessary, to give some support to the sand surrounding the pattern there, in middles for jobbing work internal fillets, *e*, are cast around the inside. Upon these, rectangular rods of wrought or of cast iron are laid, and lifters hung or placed to afford support to the sand. In middles used for standard work, bars are often cast across those sections where they



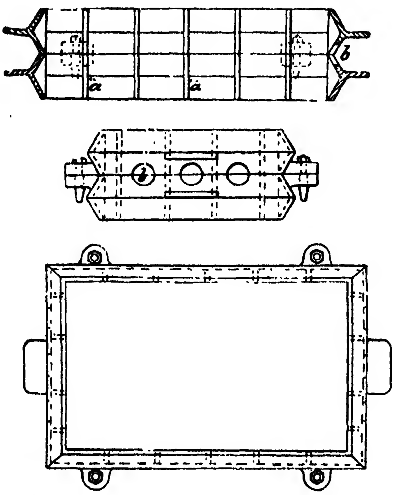
109. STANDARD SQUARE BOX



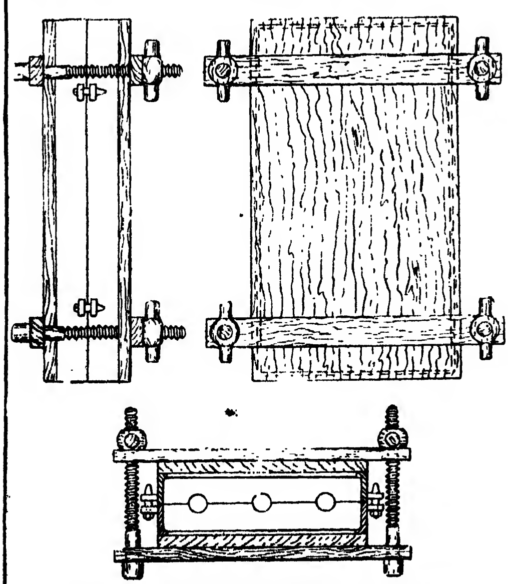
110. STANDARD ROUND BOX



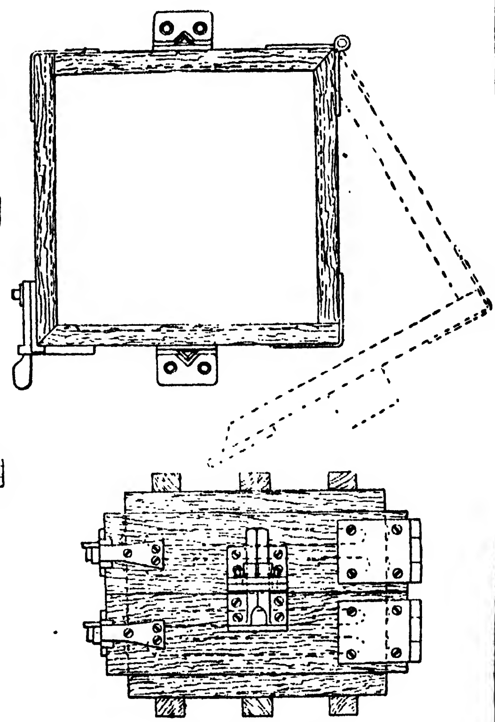
111. SMALL ROUND BOX WITHOUT BARS



112. BOX USED BY BRASS-MOULDERS



1. 3. BOX WITH BACK BOARDS AND CLAMPS



114. SNAP FLASK

109–114. MOULDING BOXES.

would be out of the way of the pattern in pouring metal.

A and C are furnished with the usual swivels *b*. But in middles, B, and other boxes of small dimensions—say, below 2 ft. 6 in.—square handles, *d*, are frequently cast, the boxes being lifted off, and, if it should prove necessary, turned over by hand.

Figs. **109** and **110** illustrate two top box parts in plan, square and round respectively, and show the arrangements of bars usual in boxes of large dimensions. Fig. **110** is for wheels and pulleys, and the central opening is left for casting the boss through.

Some Special Forms. Boxes specially for small work are shown in subsequent illustrations. Fig. **111** is a small box destitute of bars, and having only internal fillets to retain the sand. The drawing also shows the pouring of a handwheel. Fig. **112** is a box used largely by brassfounders. In these the sand is retained without ribs by the angularly recessed sides, assisted by the internal ribbings, *a*, cast in. This type of box is tilted at a slight angle from the perpendicular, and poured through the holes *b*.

The ancient type of brassmoulder's box, retained still in most shops, is shown in **113**. This also is poured on end through the holes seen. The box parts are held together by the wooden screw clamps and back boards, necessary to retain the sand during pouring. Very often the boxes themselves are made of wood and hinged, closing like the covers of a book.

Fig. **114** illustrates one of the later developments in boxes, the "snap" flask. It is hinged at one corner, and clamped at the corner opposite with a catch, so that after the mould is rammed the box is opened as indicated by the dotted outline, leaving the mould on one of the bottom boards. The great economy of this is that moulding boxes are not used to enclose the mould after its removal for casting. A ring of iron is rammed in the mould, and sustains it when out of the box. In this way one box will serve to produce dozens of moulds ready for casting. This method is, of course, suitable only for small moulds not exceeding about 12 or 15 in. across, but within these limits it is largely employed in foundries.

Weights of Castings. To be able to estimate the weights of castings correctly is of value to a moulder. To have insufficient metal in the ladle is as inexcusable an error as having a great deal too much, to be poured, perhaps, upon the floor. But as there is little time for very accurate calculation involving a large number of figures, it is well to acquire the practice of striking rapid averages, and using a few common and readily remembered figures and multipliers.

Exact methods of calculation, which are unavoidable in cases where great exactitude is required are not usually necessary when the object is only to learn the approximate quantity of metal to melt, or tap out for pouring. Some of the rules are associated together as follows.

The basis of all calculation is to estimate first the quantity of cubic inches of metal in a casting. This, of course, involves the application of the common rules of mensuration to the patterns. This need not be done exactly by text-book rules. There are many short cuts for getting at these in an approximate fashion. Cylindrical work is reckoned out in several ways. An annular ring of metal is readily reduced to a superficial plate by obtaining the circumference and multiplying that by the length. If the metal be thin, and the diameter large, no very appreciable difference will result from taking either internal or external diameter from which to deduce the circumference. But in proportion as the diameter diminishes and the metal thickens will the discrepancy increase. Hence it is necessary, in order to obtain correct results, that the *average* diameter be taken. Then that may be multiplied by $3\frac{1}{7}$, or by 3·14159 for circumference, or a proportion sum be made, thus:

7 : 22 : : diam. : circum.

Multiplying the circumference by the length and the result by the thickness gives the solid contents. Having a conical cylinder, the average diameters at each end can be taken, the circumferences deduced, these multiplied by the thicknesses, the two products added together, and divided by 2 for the average result, and this last multiplied by the length for the total solidity. Or the average diameter and thickness of the cylinder can be taken at once and multiplied by the length.

Other Methods. Another way, though not quite so ready, is to deduct the *area* in inches of the inner diameter from the area in inches of the outer diameter, which gives the area in inches of the annular ring included between them, and this, then, is multiplied by the length.

To obtain areas of circles, the exact rule is. square the diameter and multiply by ·7854. To obtain areas mentally an approximate method is to square the diameter, and deduct $\frac{1}{5}$ from the product. In a plate 12 in. diameter and 1 in. thick, this would produce an error of only 2·3 in., or a little over $\frac{1}{2}$ lb. in weight.

After a pattern has been divided up into sections, and each calculated, the *sum* of the cubic inches is taken and multiplied thus: Exact: Cubic inches × ·263 = lb. Approximate: $\frac{\text{Cubic inches}}{4}$ = lb. This is incorrect to the amount of 1·8 lb. on a plate 12 in. square and 1 in. thick, being that much below the correct weight, but is accurate enough for work not very heavy. Or allowance can be made thus: $\frac{\text{Cubic inches}}{4}$ and add $\frac{1}{20}$ of the product, which will give exactitude again. The difference between using ·263 and ·26 is only equal to ·4 lb. on a plate 12 in. square and 1 in. thick. For bringing pounds into cwts. ·009 is a simple and correct factor.

JOSEPH G. HORNER

Spanish: Use of the Subjunctive. French: Verbs.
German: Auxiliary Verbs and Interjections.

SPANISH Continued from page 2764 By José Plá Cárceles, B.A.

Imperfect and Future Subjunctive. These tenses are formed by dropping the termination *ron* from the third person plural of the past definite, and then affixing to the stem thus obtained the terminations *ra, ras, ra, ramos, rais, ran*, or *se, ses, se, semos, seis, sen*, for the imperfect, and *re, res, re, remos, reis, ren*, for the future.

IMPERFECT SUBJUNCTIVE

	Singular	*Plural*
1.	*compra-* { *ra* / *se* }	*comprá-* { *ramos* / *semos* }
	compra- { *ras* / *ses* }	*comprá-* { *rais* / *seis* }
	compra- { *ra* / *se* }	*compra-* { *ran* / *sen* }
2.	*comie-* { *ra* / *se* }	*comié-* { *ramos* / *semos* }
	comie- { *ras* / *ses* }	*comié-* { *rais* / *seis* }
	comie- { *ra* / *se* }	*comie-* { *ran* / *sen* }
3.	*cumplie-* { *ra* / *se* }	*cumplié-* { *ramos* / *semos* }
	cumplie- { *ras* / *ses* }	*cumplié-* { *rais* / *seis* }
	cumplie- { *ra* / *se* }	*cumplie-* { *ran* / *sen* }

FUTURE SUBJUNCTIVE

1. *compra-re*	2. *comie-re*	3. *cumplie-re*
compra-res	*comie-res*	*cumplie-res*, etc.

EXERCISE XXXVIII

Form the imperfect subjunctive of the following verbs:

1. *entregar* (on *ra*). 2. *aprender* (on *se*). 3. *embarcar* (*ra*). 4. *cancelar* (*se*). 5. *emitir* (*ra*). 6. *escribir* (*se*). 7. *ser* (*ra*). 8. *tener* (*se*).

EXERCISE XXXIX

Form the following subjunctive tenses:

1. Present of *estar*. 2. Future of *cantar*. 3. Imperfect of *perder*. 4. Future of *prometer*. 5. Present of *haber*. 6. Imperfect of *viajar*. 7. Future of *discutir*. 8. Imperfect of *surtir*. 9. Present of *responder*. 10. Future of *firmar*.

Use of the Subjunctive. When the infinitive or present participle which sometimes represents the second verb in an English compound phrase can by means of the conjunction "that" be changed, without altering the meaning of the sentence, into the subjunctive mood, this latter construction must always be adopted in Spanish. Thus, the phrases "He wants you to reply at once," and "I did not like their smoking in the office," may be transformed into "He wants (wishes) that you should reply at once," and "I did not like that they should have smoked in the office." These phrases must therefore be rendered in Spanish by the following: *desea que conteste Vd. enseguida*, and *no me gustó que fumaran en la oficina*.

When the subjects of the two sentences which form the phrase are identical, the infinitive of the second verb must be used instead of the subjunctive mood.—*deseo ver al gerente*, I want to see the manager.

Rules for the Subjunctive. The subjunctive mood must be employed in the following cases.

(1) After most conjunctions formed with *que*, among which the principal are the following:

a fin de que	so that	*para que*	in order that
antes que	before	*no sea que*	lest
en caso que	in case	*a menos que*	unless
sin que	without	*hasta que*	until
despues que	after	*dado que*	granted that
con tal que	provided that		

Examples are: *con tal que escriba*, provided he writes; *a menos que envien los géneros enseguida*, unless they send the goods at once.

(2) After the conjunction *si* (if) when it does not mean "whether," and the other verb in the sentence is in the conditional. In this case the imperfect subjunctive must be employed.—*si tuviera más dinero lo compraría*, if I had more money I should buy it.

(3) After the words *aunque* (even if) and *cuando* (when), in sentences implying contingency.—*escribiré aunque no tenga noticias suyas*, I will write even if I have no news from him; *iremos cuando lo terminemos*, we shall go when we finish it.

If, however, a positive statement is made, *cuando* (whenever) and *aunque* (although) must be followed by the indicative mood.—*escribiré aunque no tengo noticias suyas*, I will write although I have no news from him; *estudio cuando tengo tiempo*, I study whenever I have time. The indicative mood should also be used after *cuando* in all interrogative sentences.—*¿ cuando llegarán los reconocimientos ?* when will the bills of lading arrive ?

(4) After the adverbial expression *tan pronto como* (as soon as) in sentences which refer to the future.—*los compraré tan pronto como reciba sus instrucciones*, I shall buy them as soon as I receive his instructions.

(5) After many impersonal sentences, such as "It is probable, possible, strange, necessary,"

and the like.—*es extraño que no haya venido todavía,* it is strange that he should not have come yet; *es probable que telefonée antes de las seis de la tarde,* it is probable that she may telephone before 6 p.m.

Note that, when in sentences of this kind the subject of the second verb is not mentioned, the infinitive instead of the subjunctive should be used.—*sería mejor aguardar,* it would be better to wait; *será necesario comprobar las facturas,* it will be necessary to check the invoices.

(6) After most verbs implying emotion, such as *alegrarse,* to be glad; *sentir,* to be sorry; *temer,* to be afraid, and the like.—*me alegro de que hayan encontrado lo que deseaban,* I am glad they have found what they wanted; *tememos que no reciban el aviso á tiempo,* we are afraid they will not receive the advice in time.

(7) After certain verbs expressing a state of mind such as *desear,* to want; *dudar,* to doubt, and so on.—*¿desea Vd. que cambiemos los billetes de banco?* do you want us to change the bank-notes? *dudo que lo hayan vendido tan pronto,* I doubt their having sold it so soon.

(8) After verbs expressing command, demand, surprise, ignorance, permission, prohibition, satisfaction, supplication, advising, counselling, soliciting, entreating, and conveniency.—*nos prohibió que saliéramos,* he forbade us to go out.

(9) After superlatives or any word used in a superlative sense.—*compraré el mejor que tenga,* I will buy the best one he may have; *estoy seguro de que se concederá al primer inglés que lo solicite,* I am sure it will be granted to the first Englishman who may apply for it.

(10) In exclamations implying a wish.—*¡Dios le ampare!* May God protect him! *¡Viva el Rey!* Long live the King!

Key to Exercise XXXVI

1 ¿Le gustaría á Vd. vivir en Paris? 2 Me gustaría muchísimo. 3 ¿Que le hace falta? 4 Le hace falta más dinero para emprender un nuevo negocio. 5 ¿Sabe Vd. las señas de su primo en Madrid? 6 Sus señas eran: Calle de Murillo número 106. 7 Las mías son: Plaza de Hernán Cortés, 24, donde espero verle pronto. 8 Muchas gracias, tendré mucho gusto en visitarle el verano que viene. 9 ¿Le gusta á Vd. pasear? 10 Sí pero no hoy: hace mucho calor, y, además, estoy demasiado cansada. 11 Ahora le pesa haber aceptado el ofrecimiento sin consultar con sus socios. 12 Siempre nos hace aguardar mucho tiempo. 13 ¿Cuanto tiempo les falta para terminar su trabajo? 14 Les falta otra hora. 15 No trabajan tan de prisa como nos prometieron. 16 ¿Sabe Vd. patinar? 17 No; ¿y Vd.? 18 Me gusta patinar en el hielo. 19 Nos hace falta otro estante para poner todas esas revistas. 20 Han venido á explicárselo. 21 ¿Hacía mucho viento en el Parque esta tarde? 22 No tanto como el domingo pasado. 23 Se negará á firmar el contrato antes de recibir los informes que ha pedido. 24 Hemos invitado á su novio á comer con nosotros. 25 ¿Desea Vd. hablarle? 26 Nos prometió visitarnos durante el invierno. 27 ¿Me permite Vd. fumar? 28 Naturalmente; tome Vd. un cigarrillo mío. 29 No pude comprender lo que decía. 30 Tomamos un tranvía tan pronto como comenzó á llover. 31 Inglaterra, Gales y Escocia forman la Gran Bretaña. 32 No sé hablar italiano pero lo comprendo bastante bien. 33 No le está enseñando portugués sino español. 34 Himnos ú oraciones. 35 Infantería y caballería.

Reading Exercise

Siguiendo una costumbre establecida en tiempo de las Cruzadas y practicada constantemente por los portugueses con ocasión de sus descubrimientos africanos, los reyes Católicos solicitaron permiso de Roma para incorporar á la corona de España las tierras descubiertas por Colón. Ocupaba por aquel entonces el solio pontificio el español Alejandro VI. (sexto) el cual promulgó una bula en que se adjudicaban para siempre á España todas las islas y tierra firme, ya descubiertas ó que se pudieran descubrir en lo futuro, situadas al oeste de una línea imaginaria, trazada de norte á sur, á unas cien leguas al oeste de las islas Azores.

Translation of the Reading Exercise

Acting upon a practice established at the time of the Crusades, and constantly followed by the Portuguese in regard to their African discoveries, the Catholic kings made application to Rome for permission to incorporate in the Spanish Crown the lands discovered by Columbus. The Holy See was at the time occupied by Alexander VI., a Spaniard by birth, who issued a Bull assigning for ever to Spain all the islands and mainlands which had been, or might in the future be, discovered to the west of an imaginary line stretching between the North and South Poles, and passing 100 leagues to the west of the Azores.

Continued

FRENCH

Continued from page 2767

By Louis A. Barbé, B.A.

THE VERB

General Remarks

1. The various changes or modifications that constitute the conjugation of a verb depend on number, person, tense, and mood.

2. There are two numbers, singular and plural.

3. Each number has a first, a second, and a third person.

4. There are three principal tenses, the present, the past, and the future. Some of these admit of subdivisions, in consequence of which there are altogether eight tenses: (*a*) the present; (*b*) the imperfect, the past definite, the past indefinite, the past anterior, and the pluperfect; (*c*) the simple future, and the future anterior.

5. The tenses are (*a*) simple, or (*b*) compound. The simple tenses are those that do not require the help of an auxiliary verb. The compound tenses are those that require an auxiliary verb.

6. There are five moods: the indicative, the conditional, the imperative, the subjunctive, and the infinitive, which includes the present participle and the past participle.

7. There are two auxiliary verbs: *Avoir*, to have, and *Être*, to be.

8. *Avoir* helps to conjugate its own compound tenses, those of *être*, those of all active transitive verbs, and those of most intransitive verbs.

9. *Être* helps to conjugate the passive voice, which has really no conjugation of its own, and simply consists of the tenses of *être* with a past participle added to them.

Avoir, to have

INDICATIVE.

(a) *Simple Tenses.*

Present.

I have, etc.

j'ai	*nous avons*
tu as	*vous avez*
il, elle a	*ils, elles ont*

Imperfect.

I had, etc.

j'avais	*nous avions*
tu avais	*vous aviez*
il, elle avait	*ils, elles avaient*

Past Definite.

I had, etc.

j'eus	*nous eûmes*
tu eus	*vous eûtes*
il, elle eut	*ils, elles eurent*

Future.

I shall have, etc.

j'aurai	*nous aurons*
tu auras	*vous aurez*
il, elle aura	*ils, elles auront*

(b) *Compound Tenses.*

Past Indefinite.

I have had, etc.

j'ai eu	*nous avons eu*
tu as eu	*vous avez eu*
il, elle a eu	*ils, elles ont eu*

Pluperfect.

I had had

j'avais eu	*nous avions eu*
tu avais eu	*vous aviez eu*
il, elle avait eu	*ils, elles avaient eu*

Past Anterior.

I had had, etc.

j'eus eu	*nous eûmes eu*
tu eus eu	*vous eûtes eu*
il, elle eut eu	*ils, elles eurent eu*

Future Anterior.

I shall have had, etc.

j'aurai eu	*nous aurons eu*
tu auras eu	*vous aurez eu*
il, elle aura eu	*ils, elles auront eu*

CONDITIONAL.

Present.

I should have, etc.

j'aurais	*nous aurions*
tu aurais	*vous auriez*
il, elle aurait	*ils, elles auraient*

Past.

I should have had, etc.

j'aurais eu	*nous aurions eu*
tu aurais eu	*vous auriez eu*
il, elle aurait eu	*ils, elles auraient eu*

IMPERATIVE.

Present.

Aie, have thou
qu'il, qu'elle ait, let him, her have
ayons, let us have
ayez, have ye
qu'ils, qu'elles aient, let them have

SUBJUNCTIVE.

Present.

That I may have, etc.

que j'aie	*que nous ayons*
que tu aies	*que vous ayez*
qu'il, qu'elle ait	*qu'ils, qu'elles aient*

Past.

That I may have had, etc.

que j'aie eu	*que nous ayons eu*
que tu aies eu	*que vous ayez eu*
qu'il, qu'elle ait eu	*qu'ils, qu'elles aient eu*

Imperfect.

That I might have, etc.

que j'eusse	*que nous eussions*
que tu eusses	*que vous eussiez*
qu'il, qu'elle eût	*qu'ils, qu'elles eussent*

Pluperfect.

That I might have had, etc.

que j'eusse eu	*que nous eussions eu*
que tu eusses eu	*que vous eussiez eu*
qu'il, qu'elle eût eu	*qu'ils, qu'elles eussent eu*

INFINITIVE.

Present.	*Past.*
Avoir, to have	*Avoir eu*, to have had

PARTICIPLES.

Present	*Past.*
ayant, having	*eu* (m.), *eue* (f.), had
	ayant eu, having had

NOTE 1. The imperative has no third person, singular or plural, of its own, but borrows it from the present of the subjunctive. The imperfect of the subjunctive: *j'eusse eu*, etc., is used as a second form of the past conditional.

NOTE 2. The verb *avoir* and a noun are used instead of "to be" and an adjective in the following expressions:

avoir besoin de, to be in need of
avoir faim, to be hungry
avoir soif, to be thirsty
avoir chaud, to be warm
avoir froid, to be cold
avoir raison, to be right
avoir tort, to be wrong
avoir honte de, to be ashamed of
avoir sommeil, to be sleepy
avoir peur de, to be afraid of

NOTE 3. When *avoir chaud* and *avoir froid* are used of parts of the body, the definite article is used, and the construction is as follows: *j'ai chaud aux mains et froid aux pieds*, my hands are warm and my feet are cold. *Avoir chaud* and *avoir froid* express the sensation of warmth and cold, and are never used of

inanimate objects: *cette eau est chaude*, that water is hot; *le thé est froid*, the tea is cold. "To have a cold" is *avoir un rhume*, or *être enrhumé*.

Ne pas avoir, not to have

INDICATIVE.

Present.	*Past Indefinite.*
je n'ai pas, etc.	*je n'ai pas eu*, etc.
Imperfect.	*Pluperfect.*
je n'avais pas, etc.	*je n'avais pas eu*, etc.
Past Definite.	*Past Anterior.*
je n'eus pas, etc.	*je n'eus pas eu*, etc
Future.	*Future Anterior.*
je n'aurai pas, etc.	*je n'aurai pas eu*, etc.

CONDITIONAL.

Present.	*Past.*
je n'aurais pas, etc.	*je n'aurais pas eu*, etc.

IMPERATIVE.

Present.

n'aie pas.

qu'il n'ait pas, qu'elle n'ait pas.

n'ayons pas.

n'ayez pas.

qu'ils n'aient pas, qu'elles n'aient pas

SUBJUNCTIVE.

Present.	*Past.*
que je n'aie pas, etc.	*que je n'aie pas eu*, etc.
Imperfect.	*Pluperfect.*
que je n'eusse pas, etc.	*que je n'eusse pas eu*, etc

INFINITIVE.

Present.	*Past.*
ne pas avoir	*ne pas avoir eu*

PARTICIPLE.

Present.	*Past.*
n ayant pas	*n'ayant pas eu*

When a verb used negatively is in the infinitive the two parts of the negation, *ne pas*, remain together and come before the verb.

Avoir, conjugated interrogatively.

INDICATIVE.

Present.	*Past Indefinite.*
ai-je ?	*ai-je eu ?*
a-t-il, a-t-elle ?	*a-t-il eu ? a-t-elle eu ?*
Imperfect.	*Pluperfect.*
avais-je	*avais-je eu*
Past Definite.	*Past Anterior.*
eus-je ?	*eus-je eu ?*
Future.	*Future Anterior.*
aurai-je ?	*aurai-je eu ?*
aura-t-il ? aura-t-elle ?	*aura-t-il eu ? aura-t-elle eu ?*

CONDITIONAL.

Present.	*Past.*
aurais-je ?	*aurait-il eu ?*

Avoir, conjugated interrogatively and negatively.

INDICATIVE.

Present.	*Past Indefinite.*
n'ai-je pas ?	*n'ai-je pas eu ?*
n'a-t-il pas ?	*n'a-t-il pas eu ?*
n'a-t-elle pas ?	*n'a-t-elle pas eu ?*
Imperfect.	*Pluperfect.*
n'avais-je pas ?	*n'avais-je pas eu ?*
Past definite.	*Past Anterior.*
n'eus-je pas ?	*n'eus-je pas eu ?*
Future.	*Future Anterior*
n'aurai-je pas ?	*n'aurai-je pas eu ?*
n'aura-t-il pas ?	*n'aura-t-il pas eu ?*
n'aura-t-elle pas ?	*n'aura-t-elle pas eu ?*

CONDITIONAL.

Present.	*Past.*
n'aurais-je pas ?	*n'aurais-je pas eu ?*

Y Avoir, there to be.

INDICATIVE.

Present.

il y a, there is, there are
il n'y a pas, there is (are) not
y a-t-il ? is (are) there ?
n'y a-t-il pas ? is (are) there not ?

Past Indefinite.

il y a eu, there has (have) been
il n'y a pas eu, there has (have) not been
y a-t-il eu ? has (have) there been ?
n'y a-t-il pas eu ? has (have) there not been ?

Imperfect.

il y avait, there was (were)
il n'y avait pas, there was (were) not
y avait-il ? was (were) there ?
n'y avait-il pas ? was (were) there not ?

Pluperfect.

il y avait eu, there had been
il n'y avait pas eu, there had not been
y avait-il eu ? had there been ?
n'y avait-il pas eu ? had there not been ?

Past Definite.

il y eut, there was (were)
il n'y eut pas, there was (were) not
y eut-il ? was (were) there ?
n'y eut-il pas ? was (were) there not ?

Past Anterior.

il y eut eu, there had been
il n'y eut pas eu, there had not been
y eut-il eu ? had there been ?
n'y eut-il pas eu ? had there not been ?

Future.

il y aura, there will be
il n'y aura pas, there will not be
y aura-t-il, will there be ?
n'y aura-t-il pas ? will there not be ?

Future Anterior.

il y aura eu, there will have been
il n'y aura pas eu, there will not have been
y aura-t-il eu ? will there have been ?
n'y aura-t-il pas eu ? will there not have been ?

CONDITIONAL.

Present.

il y aurait, there would be
il n'y aurait pas, there would not be
y aurait-il ? would there be ?
n'y aurait-il pas ? would there not be ?

Past.

il y aurait eu, there would have been
il n'y aurait pas eu, there would not have been
y aurait-il eu ? would there have been ?
n'y aurait-il pas eu ? would there not have been ?

SUBJUNCTIVE.

Present.

qu'il y ait, that there may be
qu'il n'y ait pas, that there may not be

Past.

qu'il y ait eu, that there may have been
qu'il n'y ait pas eu, that there may not have been

Imperfect.

qu'il y eût, that there might be

qu'il n'y eût pas, that there might not be

Pluperfect.

qu'il y eût eu, that there might have been

qu'il n'y eût pas eu, that there might not have been

Idiomatic Uses of Avoir. 1. *Y avoir* is used with the meaning of "to be the matter": *qu'est-ce qu'il y a?* or simply *qu'y a-t-il?* what is the matter? *Avoir* without *y* is used for "what is the matter with (you, him, etc.)?" *Qu'a-t-elle?* or *qu'est-ce qu'elle a?* What is the matter with her? *Qu'avez-vous?* or *qu'est-ce que vous avez?* What is the matter with you? *Je n'ai rien*, Nothing is the matter with me.

2. Instead of "to be," and the adjective "old," *avoir* and the noun *âge* are used in French in asking or telling the age. The word *ans*, years, must always be used in the answer.

Quel âge avez-vous? How old are you?

J'ai dix-huit ans, I am eighteen.

Quel âge avait-elle? How old was she?

Elle avait seize ans, She was sixteen.

3. *Avoir* helps to form the idiomatic expressions *avoir l'air*, to look; *avoir envie*, to feel inclined; *avoir lieu*, to take place; *avoir soin de*, to take care of:

Il a l'air de mauvaise humeur, He seems to be in a bad temper.

Le loup avait envie de la manger, The wolf felt inclined to eat her up.

Nous aurons bien soin de vos livres, We shall take great care of your books.

La première représentation aura lieu demain soir, The first performance will take place to-morrow evening.

4. *Avoir*, with the adjective *beau*, forms an idiomatic expression which is placed before a verb in the infinitive to indicate the uselessness of the action expressed by that verb:

Nous aurons beau dire, on ne nous croira pas, It will be no use our saying anything (we may say what we like), we shall not be believed.

J'ai beau lui parler, c'est comme si je chantais, It is no use my speaking to him, I might as well sing (it is as if I were singing).

5. *Il y a* not only means "ago," but is also applicable to future time. It is also used with a verb in the present instead of the English perfect, or in the imperfect instead of the English pluperfect, to express an action or state, begun at a past time and still going on:

Je l'ai vu il y a quinze jours, I saw him a fortnight ago.

Il y avait trois mois que nous étions à Paris, We had been in Paris three months.

Il y aura demain huit jours que nous sommes ici, We shall have been here a week to-morrow.

Il y a une heure que je vous attends, I have been waiting for you for the last hour.

Il y avait une heure que je l'attendais, I had been waiting for him an hour.

Exercise XXI.

1. They were afraid of us, but they will be still (*encore*) more afraid of you.
2. Are they not ashamed of their conduct?
3. We should be right and you would be wrong.
4. We have been very (*bien*) cold.
5. Was there not anyone in the house?
6. How old is that child?
7. He will be twelve next month.
8. He is a little more than two years older than his sister.
9. Are you very (*bien*) hungry? No, thanks (*merci*), but I am very thirsty.
10. If there were no fire we should be very cold.
11. My hands have never been colder.
12. Will you not be too warm so near the fire?
13. I was sixteen a fortnight (15 days) ago.
14. What was the matter with those children? They were afraid of that big dog.
15. They would have been less afraid of the cat than of the dog.
16. When did the first performance of the comedy (*comédie*, f.) take place?
17. It took place a little more than six months ago.
18. If you require a dictionary, take (*prenez*) mine, but take great (*bien*) care of it.
19. We have been waiting for you for the last ten minutes.
20. It will be no use your talking; you will not be believed.

Key to Exercise XX.

Quels sont les principaux aliments qui servent à la nourriture de l'homme? Ce sont le pain, la viande, la volaille, le gibier, le poisson et les légumes. Quelle est la plante que l'on cultive pour en faire le pain? C'est le blé. Qui est-ce qui cultive le blé? Les paysans le cultivent. Quelles sont les principaux espèces de blé? Ce sont le froment, l'orge, l'avoine et le seigle. Qui sont ceux qui fauchent le blé? Les moissonneurs. Avec quoi? Avec des faux. En quoi change-t-on le blé pour en faire du pain? En farine. Qui est-ce qui change le blé en farine? C'est le meunier. Qu'est-ce que c'est qu'un moulin? C'est la machine avec laquelle le meunier change le blé en farine. Qu'est-ce que la pâte? C'est de la farine délayée avec de l'éau. Qu'ajoute-t-on à la pâte? On y ajoute du levain. Qui est-ce qui fait le pain? C'est le boulanger qui fait le pain. Qu'est-ce-que le pain rassis? Le pain qui n'est pas frais. Quels sont les animaux dont on mange la chair? Ce sont le bœuf, le veau, le mouton. Qu'est-ce que c'est que la viande de boucherie? C'est la chair des animaux domestiques. Qu'est-ce que le gibier? On nomme gibier les animaux qui ne sont pas des animaux domestiques et dont on mange la chair. Quels sont-ils? Le cerf, le chevreuil, le sanglier, le lièvre. Qui sont ceux qui tuent ces animaux? Ce sont des chasseurs. Avec quoi les tuent-ils? Avec des fusils. Mange-t-on la chair des oiseaux? Oui, il y a des oiseaux dont on mange la chair. Lesquels? La poule, le dindon, le canard et l'oie. Y a-t-il d'autres oiseaux dont la chair est bonne à manger? Oui, il y a d'autres oiseaux dont la chair est bonne à manger; ce sont des oiseaux sauvages tels que la perdrix, la bécasse, la bécassine, le faisan et le coq de bruyère. Quelles sont les différentes espèces de poissons? Il y a les poissons de mer et les poissons d'eau

douce. Qu'est-ce que l'eau douce ? L'eau des lacs, des étangs, des rivières et des ruisseaux. Quels sont les poissons de mer les mieux connus ? Ce sont la morue, le hareng, l'éperlan, le maquereau, la sole, le turbot, le merlan et la raie. Et ceux d'eau douce ? Le saumon, la truite, la carpe, la perche, et le brochet. Qui sont ceux qui attrapent le poisson ? Ce sont des pêcheurs. Avec quoi ? Avec des lignes et des filets. Qu'est-ce qu'on mange avec la viande ? Des légumes. Qu'est-ce que les légumes ? Ce sont des plantes qui servent aussi à la nourriture de l'homme. Quels sont les principaux légumes que l'on cultive en France ? Les pommes de terre, les choux, les betteraves, les carottes, les asperges, les fèves, les haricots et les pois. Qu'est-ce qu'un potager ? C'est le jardin ou terrain où l'on cultive les légumes. Et un verger, qu'est-ce que c'est que cela ? C'est le terrain où il y a des arbres fruitiers. Quels sont les principaux arbres fruitiers et leurs fruits ? Le poirier dont le fruit est la poire ; le cerisier qui produit les cerises ; le pêcher sur lequel croissent les pêches ; le brugnon dont le fruit a le même nom que l'arbre ; le prunier et l'abricotier qui nous donnent les prunes et les abricots et le pommier avec le fruit duquel on fait le cidre. Quelle est la plante que l'on cultive pour en faire le vin ? C'est la vigne. Quel est le fruit de la vigne ? C'est le raisin.

Continued

GERMAN

Continued from page 2762

By P. G. Konody and Dr. Osten

XLIX. Use of Auxiliary Verbs of Tense. The auxiliary verb werden, to become, to grow, is employed with *all* verbs for the formation of the first and second future, of the two conditionals in the active voice, and of *all* tenses in the passive voice. The *infinitive past*, the *perfect* and *pluperfect* of all verbs are formed with the aid of either (*a*) sein, to be, or (*b*) haben, to have. Certain verbs form these compound tenses (*c*) alternately with sein or haben.

(*a*) The majority of verbs are conjugated with haben—especially the *transitive*, *reflective*, and *impersonal* verbs denoting actions and lasting effects of actions, and some *intransitive* verbs.

(*b*) With sein are conjugated many *intransitive* verbs, especially those denoting change of locality, motion and transition into other states. To this class belong the verbs with the prefixes indicating motion—her-, hin-, herab-, hinauf-.

(*c*) Some transitive and intransitive verbs admit the use of both sein and haben, according to the state of action, motion, etc., which is to be expressed. Examples: ich bin geeilt, and ich habe geeilt, I have hurried; or: ich bin geritten and ich habe geritten, I have ridden, etc. In these cases haben is used where the action of the subject is a more accentuated, settled process of activity; whilst sein indicates transitions from one state into another. With sein are conjugated: begeg'nen, to meet; folgen, to follow; liegen, to lie, lay; sitzen, to sit; stehen, to stand; weichen, to yield, to give way; glücken, gelin'gen, to succeed; missglücken, missraten, misslingen, to fail; and gehen, to go, to walk. Thus gehen is conjugated with sein: ich bin gegangen (literally: I am gone); but in the reflective form: ich habe mich müde gegangen, I have walked myself tired (I have tired myself out with walking). Frequently the *general*, unspecified character of the action is denoted by the use of haben, and the special one by the use of sein. Thus to express in a *general* way that one has been on horseback, one would say: ich bin geritten, (literally: I am ridden); but ich habe das Pferd geritten, (I have ridden the horse; or ich bin zur Mühle geritten (literally: I am ridden to the mill), but ich habe das Pferd zur Mühle geritten (I have ridden the horse to the mill).

1. Several *intransitive* verbs, like the following, are conjugated with haben: zu'nehmen, to increase; ab'nehmen, to decrease; an'fangen, begin'uen, to begin; auf'hören, to cease; blühen, to blossom; brennen, to burn; bellen, to bark; fechten, to fight; glühen, to glow; lachen, to laugh; leuchten, to light; nach'lassen, to leave off; ruhen, to rest; scheinen, to shine; schlafen, to sleep; wachen, to watch; weinen, to weep, cry, etc. Ich habe die Arbeit aug fangen, I have begun the work; and *intransitive*: die Arbeit hat angefangen, the work has begun; and in the *passive* of the transitive: die Arbeit ist angefangen, the work is begun.

2. The following verbs are conjugated either with sein or haben: eilen, to hasten; fahren, to drive; hängen, to hang; knieen, to kneel; kriechen, to creep; laufen, to run; liegen, to lie (in the physical sense); reiten, to ride; schweben, to be suspended; schwimmen, to swim; sitzen, to sit; springen, to jump; stehen, to stand; stolpern, to stumble; treten, to tread; wandern, to wander. Thus: ich bin or ich habe gekniet (I have knelt); ich bin or ich habe geschwommen (I have swum).

L. Interjections. As in English, the interjections denote joy, sorrow, surprise, fear, horror, etc., or call attention to something. Those chiefly in use are: O! Ah! Ha! Ach! (for surprise); O weh! Au! (for pain); Brrr! (to express coldness and shuddering); Aha! (used like "I see," to express understanding); I! Ei! or Ei Ei! Hm Hm! (for wonder or surprise); Pfui! (fie! for shame!); Heda! Hollah! He! Pst! (for calling attention, like the English "I say!"); and several imitative sounds like Plumps! Husch! Piff Paff Puff! (to mark a sudden disappearance or a sudden fall into water, mostly used in fairy tales and nursery tales, also the firing of guns). These latter and similar interjections, like Rumwidibum! Schnedderengeng! (in imitation of drums and brass instruments) are used in a semi-humorous way in descriptions of folklore character. Hoch! Hurrah! Heil! are interjections for cheering; Prost! (or Prosit!)

for drinking. Zeter und Mor'dio! Bomben und Grana'ten! Himmel und Hölle! are exclamations of anger and force, akin to swearing. The military command of Fire! Feuer! as well as the fire-call, Feu'rio! are counted among the interjections. The interjections are often combined with the fifth case, the vocative, which is treated in the next paragraph.

LI. The Vocative Case. This, the fifth case in the declension of nouns, is the mode of address, and is thus employed only with persons, with personal pronouns in the second person, and with nouns personified: Du (vocative) schreibe! Thou write! (imperative). Ihr (vocative) gehet! You go! Meine Vorfahren! My ancestors! Du, mein lieber Vater! Thou, my dear father! Du tapferes Schwert! Thou brave sword!

The vocative is also used with interjections: O Gott! O Himmel! (Oh God! Oh Heaven!), and in many other exclamations. It also serves for the mode of address in letters: Geehrter Herr! [Honoured] Dear sir. Bester Freund! [Best] Dear friend. The vocative has traits similar to the imperative and the interjection, and is often employed with them. As regards inflection, the vocative is identical with the nominative.

LII. The following strong verbs with the stem-vowel -a- change it in the imperfect into -ie-, or -u-, but retain the original stem-vowel in the past participle.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
blasen	to blow	ich blase, bläsest, bläst	ich blies	ich bliese	blas(e)	geblasen
braten	to roast	„ brate, brätst, brät (bratest, bratet)	„ briet	„ briete	brat(e)	gebraten
empfangen	to receive	„ empfange, empfängst, empfängt	„ empfing	„ empfinge	empfang(e)	empfangen
fallen	to fall	„ falle, fällst, fällt	„ fiel	„ fiele	fall(e)	gefallen
fangen	to catch	„ fange, fängst, fängt	„ fing	„ finge	fang(e)	gefangen
gefallen	to please	„ gefalle, gefällst, gefällt	„ gefiel	„ gefiele	gefall(e)	gefallen
geraten	to come upon	„ gerate, gerätst, gerät	„ geriet	„ geriete	gerat(e)	geraten
halten	to hold	„ halte, hältst, hält	„ hielt	„ hielte	halt(e)	gehalten
hangen *	to hang	„ hange, hängst, hängt	„ hing	„ hinge	hang(e)	gehangen
lassen	to let	„ lasse, lässest, läßt	„ ließ	„ ließe	laß	gelassen
mißfallen	to displease	„ mißfalle, -fällst, -fällt	„ mißfiel	„ mißfiele	mißfall(e)	mißfallen
raten	to advise	„ rate, rätst, rät	„ riet	„ riete	rat(e)	geraten
schlafen	to sleep	„ schlafe, schläfst, schläft	„ schlief	„ schliefe	schlaf(e)	geschlafen
backen	to bake	„ backe, bäckst; bäckt	„ buk (backte)	„ büke (backte)	back(e)	gebacken
fahren	to drive	„ fahre, fährst, fährt	„ fuhr	„ führe	fahr(e)	gefahren
graben	to dig	„ grabe, gräbst, gräbt	„ grub	„ grübe	grab(e)	gegraben
laden	to summon, charge, load	„ { lad-e, -est, -et or lade, lädst, lädt }	„ lud	„ lüde	lad(e)	geladen
schaffen †	to procure, provide	„ schaff-e, -st, -t	„ schuf	„ schüfe	schaff(e)	geschaffen
schlagen	to strike	„ schlage, schlägst, schlägt	„ schlug	„ schlüge	schlag(e)	geschlagen
tragen	to carry	„ trage, trägst, trägt	„ trug	„ trüge	trag(e)	getragen
wachsen	to grow	„ wachse, wächst, wächst	„ wuchs	„ wüchse	wachs(e)	gewachsen
waschen	to wash	„ wasche, wäschest, wäscht	„ wusch	„ wüsche	wasch(e)	gewaschen

* As intransitive (without complement), *strong;* as transitive, *weak*, hängen (aufhängen); imperative: hängte; past participle: gehängt.

† In the sense of "to work" *weak:* Hier wird nichts geschafft (gearbeitet). Here is nothing done.

LIII. The following strong verbs with the stem-vowel -o-, -u-, -au-, or -ei- change it in the imperfect into -ie-, but retain the original stem-vowel in the past participle.

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
stoßen	to push	ich stoße, stößt, stößt	ich stieß	ich stieße	stoß(e)	gestoßen
rufen	to call	„ rufe, -st, -t	„ rief	„ riefe	ruf(e)	gerufen
laufen	to run	„ laufe, läufst, läuft	„ lief	„ liefe	lauf(e)	gelaufen
heißen	to name	„ heiße, heißest, heißt	„ hieß	„ hieße	heiß(e)	geheißen
hauen	to hew	„ haue, -st, -t	„ hieb	„ hiebe	hau(e)	gehauen

LIV. Irregular changes of the stem-vowels are to be noted in the following verbs:

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
erschal'len	to resound	er, sie, es erschallt	erscholl	erschölle	erschall(e)	erschollen
schwören	to swear	ich schwöre, -st, -t	ich schwor, also schwur	ich schwöre (schwüre)	schwör(e)	geschworen
verlö'schen*	to be extinguished, go out	„ verlösche, verlöschest, verlöscht	ich verlosch	„ verlösche	verlösch(e)	verloschen
stehen	to stand	„ steh-e, -st, -t	ich stand, also stund	„ stände (stünde)	steh(e)	gestanden
kommen	to come	„ komm-e, -st, -t	ich kam	„ käme	komm	gekommen
lügen	to lie	„ lüg-e, -st, -t	„ log	„ löge	lüg(e)	gelogen
tun	to do	„ tu-e, -st, -t; wir tun (subj. ich tu-e, -est)	„ tat	„ täte	tu(e)	getan
schinden	to flay, skin	„ schind-e, -est, -et	„ schund	„ schünde	schind(e)	geschunden

* The transitive compound of löschen: auslöschen is weak: Er hat das Feuer ausgelöscht, He has extinguished the fire.

EXAMINATION PAPER

1. For the formation of which tenses is the auxiliary verb werden used?
2. With which auxiliary verb of tense are the majority of verbs conjugated, and to which groups of verbs does this rule most particularly apply?
3. How does the character of a verb (its being transitive or intransitive, reflective or impersonal) determine the use of sein or haben in the formation of compound tenses?
4. With which verb is the auxiliary verb sein employed?
5. In what state of action is the auxiliary verb haben used for the formation of the compound tenses?
6. What circumstances determine the use of sein or haben in the compound tenses of the verb reiten, to ride (on horseback)?
7. What is the characteristic feature in the formation of the past participle of many strong verbs that change the stem-vowel -a- into -ie- or -u- in the imperfect?
8. Which vowel is taken in the imperfect by verbs with the stem-vowel -o-, -u-, -au-, and -ei- in the infinitive and past participle?

Exercise. Transpose the following tenses from the past and pluperfect to the imperfect.

Ich habe die Trompete geblasen; du hattest
I have blown the trumpet; you had re-
ihn empfangen; die Feinde haben den Offizier gefangen;
ceived him; the enemies have captured the officer;
sie hat mir gefallen; das Kind ist gewachsen;
she has pleased me; the child has grown;
die Frauen hatten die Wäsche gewaschen;
the women had washed the washing;
wer hat mich gerufen? Du bist schnell gelaufen;
who has called me? You have run quickly;
er hat mich gestoßen; wann seid ihr gekommen?
he has pushed me; when did you come?
(have you come?)
Der Bursche hat gelogen; er hatte einen Eid geschworen.
The lad has lied; he had sworn an oath.
Was haben Sie getan? Ich habe es getragen.
What have you done? I have carried it.
Wir waren eben nach Hause gekommen;
We had just come home;
ich habe meine Pflicht getan.
I have done my duty.

Key to Exercise 3, Page 2833

Nachdem die Damen sich zurückgezogen hatten, rauchten wir; weil Niemand uns die Tür öffnete gingen wir fort; ehe ich ihm ein Wort sagen konnte verschwand er; wenn es genügend viel regnet, wächst der Weizen; ob ich zürne, frug er mich; falls das Wetter es zuließe, wünschte er abzureisen; als er kam schlief ich; da man sie bat, es zu tun, sang sie ein Lied. solange Sie es mir nicht zugesagt haben, gehe ich nicht fort.

Keys to Exercises in the Examination Paper in Page 2760

Exercise 1. Ich kenne einen Mann, der verheiratet ist; ich sprach mit der Frau, deren Mann krank ist; dies sind die Kinder, welche wir gestern im Walde trafen. Kennen Sie die Mädchen, deren Brüder Tennis spielen? Ich begeg'nete der Frau, deren Mann beim Schiffbruch um'kam; dies ist der Knabe, der mich durch den Wald führte. Er ist ein Mann, dessen Güte allgemein bekannt ist.

Exercise 2 (*a*). Der Soldat ficht tapfer; der Wind bewegt die Zweige der Bäume; der Sonnenun'tergang bewegt mich umzukehren; das Mädchen flicht einen Kranz; er hebt das Faß; die Schäfer scheren die Schafe; die Knaben fliehen; das Wasser fließt rasch.

(*b*) *Imperfect:* Sie genossen nicht, etc.; die Schlange kroch, etc.; das Wasser sott; der Jäger schoß vorzüglich; ich verlor mein Geld; ich verbot, etc.; die Blumen rochen gut; ich glaube der Mann betrog mich; die Pflanze sog, etc.

Perfect: Sie haben nicht die Schönheit der Landschaft genossen; die Schlange ist über den Weg gekrochen; das Wasser hat gesotten; der Jäger hat vorzüglich geschossen; ich habe mein Geld verloren; ich habe Ihnen dies ernstlich verboten; die Blumen haben gut gerochen; ich glaube der Mann hat mich betrogen; die Pflanze hat ihre Nahrung aus dem Boden gesogen (or gesaugt).

Exercise 3. Er ist nicht jedermanns Freund. Wo man geboren ist, dort heimelt es einen an; es ist nicht jedermanns Geschmack zu streiten; haben Sie etwas gehört? Nein, ich habe nichts gehört; ich glaube niemand(em), den ich nicht kenne. Jemandes Hand muß dabei im Spiele gewesen sein.

Continued

The Making and Dressing of all Kinds and Makes of Shirts. Drafting, Cutting, and Finishing. Collar Making.

SHIRT AND COLLAR MAKING

Forty or fifty years ago shirtmaking was one of the cottage industries of England, but the general adoption of the sewing-machine and its introduction to the factory system of working brought about a change in this class of work.

Cutting Out the Material. In the factory the first thing is to cut out the material in the most economical manner. This is done by laying out a number of folds of the material to be used, and placing the various parts of the pattern, which are usually cut out first of all in tin or stout cardboard, and, after these have been marked round in pencil, cutting them out with a hand-knife or band-saw in as many thicknesses as required for the different sizes. For domestic or individual work, of course, a different plan is adopted, but it is equally important to arrange the pattern so as to use as small a quantity of material as possible.

The various parts of the shirt having been cut, the body part from calico, and fronts, cuffs, and collars from linen, the supplementary parts have next to be attended to, such as the underlining for the cuffs, which is usually a fabric composed of a mixture of linen and cotton, and the backing for the fronts. The quality of a shirt is generally made to depend upon the fineness of the linen employed in making the front and cuffs, which is reckoned according to the number of threads to the inch, as counted through a magnifying-glass specially made for the purpose.

The various parts of the different kinds of shirts will be seen by reference to the diagrams, and these are put together by the ordinary methods of sewing, the main objects being to fit the body without causing discomfort at any part.

The buttonholes should be very neatly worked, and a sewing-machine for working buttonholes is largely used in all shirt and collar factories. This machine, by means of a kind of cross-stitching, does the sewing before the hole is cut, this being done by a chisel, or similar tool, after the shirt or collar has been finished and dressed—that is, starched and ironed. Care should be exercised in seeing that the buttonholes harmonise as regards position, that the hole in the back of the collar be exactly in the centre, and that those of the cuffs are properly balanced.

Material for Shirts. The material used for making shirts is a calico, in the trade termed longcloth, varying from 34 in. to 37 in. in width, the price ranging from 5½d. to 10d. per yard—retail—according to quality required.

The quantity of material required for two shirts with stiff fronts and wrists would be 6 yd. longcloth, 1 yd. Irish linen for frontings, and 1¼ yd. of heavy interlining. The interlinging might be either linen or cotton.

The wristbands are usually made fourfold—which accounts for the extra length of interlining—to resist the greater wear on them generally. Cottons Nos. 40 to 45, 6-cord, would be suitable for body-making, but for fronts, wristbands, and buttonholes, 60, 6-cord, would be best. For needles, Singer's ½ would be found most suitable for the purpose. The material for flannel day-shirts varies from 3 yd. to 3½ yd. These are, of course, easier to make, owing to their being no stiff fronts or wristbands to be inserted. The cloth is folded in the same way as for dress-shirts, but instead of cutting away a piece for the insertion of the stiff front, a piece of cloth about two inches wide is stitched down the centre, so as to form a broad plait when buttoned over. Then slope out the neck according to the size required. The neckbands of these shirts are generally made of drab or grey sateen.

The wristbands are cut so as to fit just round the wrist about 2½ in. or 3 in. deep. Pearl buttons are used for fronts and wristbands. Owing to the greater strength required of these shirts for day-work generally, the same should be made up with 6-cord cotton, 45 to 50.

Linen Collars. The quantity of material required varies according to the shape of collar. The cloth used for fronting is generally Irish linen, which dresses up so much better than cotton, and imparts a higher finish to the collar when dressed, and wears longer.

The collar can be lined with either a heavy cotton or linen interlining, but the latter would be more durable, and would be found cheaper in the end. The material for collars varies from 34 in. to 36 in. in width. Singer's 0 needles are suitable for collar-making. Collars should be made up in 6-cord, 60 to 80, cotton.

Diagram 9 gives reduced models of some of the most popular styles of collars, which only need to be reproduced by the ordinary inch-tape to give a good model. The patterns given may be reduced in height if necessary, to suit prevailing fashion.

The variations in size can be easily made by adding to or taking from the back.

"Dressing." A new shirt should first be placed in cold water for the purpose of taking out the dress or priming of the cloth of which it is made, and afterwards taken out and washed as household linen, being thoroughly well dried in the open air before starching. While the shirt is drying, lump borax should be dissolved in the proportion of 4 oz. to 6 oz. in one pint of boiling water to half a dozen shirts. The starch (which should always be good rice-starch) should then be prepared. Take 1 lb. of starch; add a little blue, which gives the shirt a whiter appearance when dressed; mix the starch in a little cold water; then add water in which the borax has been dissolved, which, however, should first be allowed to cool. The shirt being thoroughly dry, first take hold of the wristbands and well soak and rub in the starch that has been prepared, and then deal with the front in the same way. The wristbands should next be rolled to front tightly, and the shirt allowed to remain three or four hours, if possible. It could be ironed immediately if required, but in this case it would need to be first rolled in a dry cloth, or rubbed down with a dry cloth to take off the surface starch and superfluous moisture. If the starch appears rather thick when rubbing, add a little water to reduce it.

Ironing. First set or lay out flat the yoke of the shirt, then neckband, and afterwards the body, seam to seam.

Iron the body of shirt first, then "set" the cuffs and iron the sleeves. When this is done, prepare the front. Place a board (which should be covered with a piece of ironing flannel) between back and front of shirt, and then set for ironing. Next take an oval iron, or polisher, well heat it, and then take a piece of rag upon which a piece of beeswax has been placed, and rub the iron lightly with this, which will cause the iron to run smoothly over the starched front and wrists. But, before using, wipe again with a clean duster, to remove any particle of beeswax that might be sticking to the iron. Then, with the heel of the polisher, rub briskly, using the point or nose of the iron around neckband. When ironed, fold and press with flat-iron, well air, and the shirt is will be ready for use.

For the washing, drying, starching, etc., of collars the same process is used as for shirts, but the quantity of starch quired depends upon the number of articles to be dressed.

White shirts are made up in many varieties of fronts and cuffs. Thus the dress-shirt has a front 14 in. or 15 in. deep, and about 11 in. wide, with one stud-hole in the centre about 5 in. or 6 in. down from the collar.

The ordinary or everyday shirt has a front from 11 in. to 13½ in. long, and 8 in. to 9 in. wide, with two or three buttonholes up the front.

Short-fronted shirts are also made for those who wear high-buttoning vests, and the newest style of these are V-shaped, which gives much more comfort than the old round pattern.

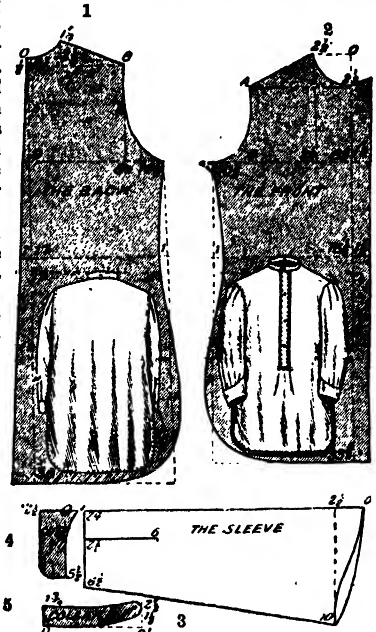
Many shirts are now made up with soft fronts, or, in other words, without the insertion of any kind of front, and it is to this class that the flannel shirt belongs.

Cuffs are usually placed at the wrists, but many are now made with detachable cuffs. Occasionally shirts are made up with collars attached, but this is the exception.

The fastening can either be arranged up the front or the back, but the latter plan is preferred. A slit is made about 12 in. deep, and a facing seamed on and the neckband arranged accordingly.

Football shirts are made up in all kinds of patterns, according to the club selection. They are usually finished at the neck with a turnover collar, and a patch pocket on the breast.

The night-shirt is made longer and fuller than the day-shirt, but, generally speaking, is of the same design. It is finished at the neck with a turnover collar and a breast pocket. Occasionally the bottom of the back is cut ten or twelve inches longer, turned up to form a pocket for the feet.



1–5. THE SAC SHIRT

An excellent book on cutting and making all kinds of shirts is published by the John Williamson Co., Ltd., Gerrard Street, W., from whose pages we have reproduced the following system of cutting the two principal styles.

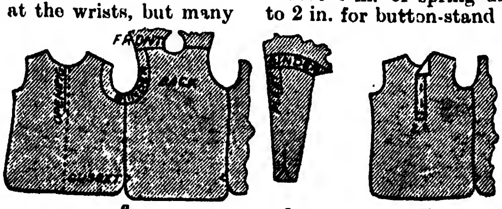
Taking the Pattern. We first proceed to describe the system, and, in order to make it as simple as possible, we have selected a style of shirt which is very free of complications, and will describe the cutting of this by divisions of the breast-measure system, for which the ordinary measures of length and width, the same as for a coat, will suffice.

THE BACK [1]. Draw line O 36 and mark off as follows: O to ½, ½ in. O to 9, one-sixth breast plus 3 in. O to 17 the natural waist length. O to 36 the full length desired plus the seams. O to 2½ one-sixth neck. From these points square lines across at right angles.

2½ to 1¼ one-twelfth neck, and curve back neck. 1¼ to 8 the width of shoulder, as taken on customer, plus two seams. Square down from 8 to 8*. 9 to 10½ one-fourth breast plus 1½ to 2½ in. Square down from 10½, and hollow on line 17 1 in., and add on 1 in. of spring over the seat. Mark out from 17 1 in., and draw line from O through 1.

THE FRONT [2]. Draw line O 33½. O to 2½ one-sixth neck. O to 8½ one-sixth breast plus 2½ in. O to 16½ natural waist length less ½ in., or by making the distance from 8½ to 16½ the same as 9-17 of the back. 16½ to 33½ 2 in. less than 17 to 36 of the back. Square lines from O, 2½, 8½, 16½, and 33½. O to 2½ one-sixth of the neck. 2½ to A the same as 1¼ to 8. 8½ to 8 one-fourth breast less 1in. 8½ to 10½ one-fourth breast plus 1½ in. to 2½ in. Hollow waist 1 in.

Give 1 in. of spring under the hips. Add on 1½ to 2 in. for button-stand and front pleats.



6–8. FITTING THE SHIRT TOGETHER

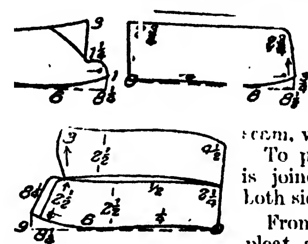
THE SLEEVE AND CUFF [3 and 4]. Draw line O 24. O to 2½, 2½ in. to 3½ in., the smaller quantity for easy-fitting sleeve. O to 24 the length of sleeve less cuff and shoulder-width, due provision being made for seams. 2½ to 10 half scye plus 1 in. to 1½ in. 24 to 6½ one-sixth breast plus ½ in. Cut as in under part, about 2 in. or 2½ in. from crease.

For the cuff [4] draw lines O 2¼, O 5½. O to 5½ half size of cuff desired, plus 1 in. O to 2¼ depth of cuff desired plus ½ in. Add on point at 1 or shape to taste. The cuff may be varied considerably, and this is but one style of many.

THE COLLAR [5]. Draw line O 8½. O to 8½ half neck plus 1 in. 8½ to 1¼, 1¼ in. Draft collar

$1\frac{3}{4}$ deep at back and 1 in. deep at front. In the accompanying diagrams we give a few suggestions on making up. Diagram **6** shows the back joined to the front at the shoulders and the side; about 2 in. from the bottom of the side-seam a gusset is put. The opening is cut down the front about $\frac{3}{4}$ in. to the right of the centre and about 13 in. deep. This is then turned in, and forms the button-stand, while the other side is turned in to form a pleat, and the under part turned over to meet it, the holes being worked in this as shown in **7**.

In **8** we show the sleeve made up; the fulness at the top may either be put in the form of pleats or gathers, which also applies to the cuff; the slit of the sleeve should be faced so as to take buttons if necessary. Binders are often put on round the armhole in order to strengthen it at that part. These are shown in **6** and **8**.

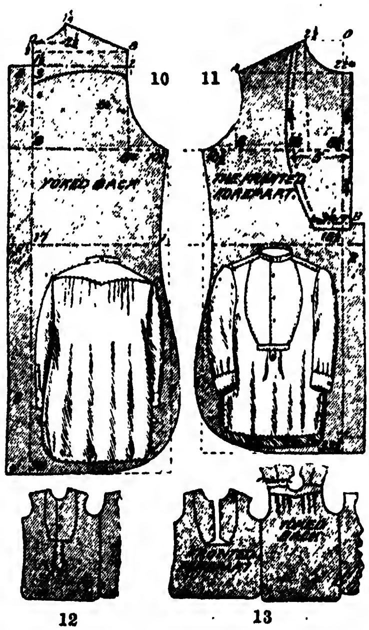


9. COLLAR DRAFTING
A. The "Wing" B. The "Stand" C. The "Double"

Yoked and Fronted Shirts.

The vast majority of shirts are now made up with yokes and inserted front. This plan is now adopted not only for white and coloured linen shirts, but also for flannels, so that this is by far the most popular style of shirt at the present time. These two features do not necessarily go together; the yoked back may be used with the plain fore part [**2**], or the fronted fore part may be used with the sac back [**1**].

THE YOKE BACK [**10**]. Draw line O 36. O to $\frac{1}{2}$, $\frac{1}{2}$ in. O to 3, 3 in. more or less to taste. O to 9 one-sixth breast plus 3 in. O to 17 natural waist length. O to 36 full length of back plus two seams. Square lines at right angles to these points. O to $2\frac{1}{2}$ one-sixth neck. $2\frac{1}{2}$ to $1\frac{1}{4}$ one-twelfth neck, and curve back neck. $1\frac{1}{4}$ to 8 the width of shoulder plus two seams ($\frac{1}{2}$ in.). Square down from 8 to 8*. 9 to $10\frac{1}{2}$ one-fourth breast plus $1\frac{1}{2}$ in. to $2\frac{1}{2}$ in. Square down from $10\frac{1}{2}$. Hollow inside this line 1 in. at waist, and add 1 in. of spring over the seat. Shape bottom of yoke to taste. In the diagram it is pointed in the centre, which is 3 in. down from O. The depth at the scye is 2 in. Let back overlap this at the shallowest part at least $\frac{1}{2}$ in., as shown by dot and dash line.



10–13. YOKED AND FRONTED SHIRT

THE FORE PART [**11**]. Draw line O $33\frac{1}{2}$. O to $2\frac{1}{2}$* one-sixth neck. O to $8\frac{1}{2}$ one-sixth breast plus $2\frac{1}{2}$ in. $8\frac{1}{2}$ to $16\frac{1}{2}$ the same as the back from 9 to 17. $8\frac{1}{2}$ to $33\frac{1}{2}$ about 2 in. less than 9 to 36 of the back. $8\frac{1}{2}$ to $2\frac{1}{2}$, and O to $2\frac{1}{2}$, each one-sixth of the neck.

Square across from $2\frac{1}{2}$* to A, and make $2\frac{1}{2}$ to A the same width as $1\frac{1}{4}$ to 8 of the back.

$8\frac{1}{2}$ to 8 one-fourth breast less 1 in. $8\frac{1}{2}$ to $10\frac{1}{2}$ one-fourth breast plus $1\frac{1}{2}$ in. to $2\frac{1}{2}$ in.

Square down from $10\frac{1}{2}$.

Hollow side-seam at waist 1 in., and give about 1 in. of spring over the hips.

THE FRONT. The shape of the front varies considerably, but the more general size is that indicated on this diagram.

The depth extends to within 1 in. or $1\frac{1}{2}$ in. of waist line, $16\frac{1}{2}$. The width of the front at the bottom is $3\frac{1}{4}$ in., including the $\frac{3}{4}$ in. button-stand added beyond the centre line.

The width across the widest part of the breast just below the depth of scye line is 5 in., including the $\frac{3}{4}$ in. button-stand. From this point it is continued up to the shoulder seam, where it is made 1 in. wide.

To provide for seams where the front is joined at the breast, allow $\frac{3}{8}$ in. at both side and bottom.

From B downwards allow 2 in. for pleat at bottom of the front.

The sleeve, cuff, and collar are as described on **3**, **4**, and **5**, though in the illustration we show a plain round cuff that, however, is a variation which may be easily introduced.

Important Details.

The yolk is intended to be double.

The extra width of the back is either gathered or pleated in to the yoke just above the blades on either side of the point, leaving about $1\frac{1}{2}$. in. plain on either side of the point. This is shown in **13**, as well as the joining of the fore part to the yoke.

In **13** we also illustrate the front sewn to the fore part down the sides, from which it will be seen there is extra width on the fore part below to be gathered or pleated in. This is generally done by a box-pleat, and the bottom of front is either finished with a strap or the front is left long enough to overlap the necessary amount.

On the figure in **11** we illustrate the strapping method, and in **12** the plain method.

These fronts are either made double or of more thicknesses.

When working-men's shirts are made up from Oxford shirting in this way, the lining of the front is of unbleached calico.

When flannel shirts are made up in this way, the inner front may either be of the same flannel or a thinner one.

The number of holes put in the fronts is usually three, though for dress-shirts this number is sometimes reduced to one.

For white linen or cambric shirts, fronts are made up with four thicknesses, to take the starch, and in this case the cuffs follow suit.

A tab is often put on the bottom of the front to fasten it to the top button of the trousers.

All the seams are turned in and stitched or felled, and are never left raw. This necessitates the provision of rather wider seams than the usual $\frac{1}{4}$ in., so that they ought not to be less than $\frac{3}{8}$ in. or $\frac{1}{2}$ in. The bottom side-seams are left open about 3 in. or 4 in. up, and the top of the slit is finished off with a gusset

The Steel Trade in Relation to Knives and Razors.
Razors: Grading, Tempering, and Grinding.

CUTTING INSTRUMENTS

Sheffield is the ancestral home of the cutlery industry. When Crecy and Agincourt were shaping history, the English arrows made in Sheffield "were so sharp that no armour could repel them." A Government order is on record of 5000 arrow-heads at 15d. per hundred. The importance of this early industry is stereotyped in the bundle of arrows crossed which appears in the coat of arms of the city. In Chaucer's "Reeve's Tale" the miller carried "a Scheffield thwitel in his hose." The thwitel is the whittle or whittling knife.

In Sheffield, methods have been transmitted to successive generations through the centuries, which sarcastic people now term rule-of-thumb, but which nevertheless have made the city the Mecca of the metallurgist. The methods of the steel-maker and the cutler are of the nature of acquired characteristics, crystallised permanently.

The History of Cutlery Steel. Three great epochs stand as landmarks in the industrial history of the ancient town: the introduction of the crucible-cast steel process by Benjamin Huntsman in the eighteenth century; the introduction of the Bessemer and the Siemens steel-making processes in the middle of the nineteenth century; and the invention of Mushet steel in 1868, the parent of the high-speed tool-steels which have radically changed the practice of metal cutting in the engineers' machine-shops, increasing the output, and entailing as a consequence a radical re-designing of machine-tools to fit them for the vastly increased cutting powers of the new steels. Each of these movements has exercised a profound influence on the manufacture of cutlery and tools.

All the early steels available previously to the discovery of Huntsman were blister or cement steels manufactured by the same essential methods as those which have been practised in India, Burma, and Africa from an unknown antiquity to the present time; that is, by contact either of iron ores or of iron bars with a carbonaceous material at a high temperature, prolonged during several days. Charcoal supplies the necessary carbon to the iron bars, and the resultant gases produce the blisters, whence the term "blister steel." The best qualities of steel are still produced in this way, using charcoal, and the process is termed the cementation process. Bundles of blister steel raised to a welding heat and hammered produce the "shear steel" and "double-shear" steel from which all the early cutlery and tools were forged. No other was available previously to about 1750, when Huntsman was perfecting his discoveries.

Kinds of Steel. The great and essential difference between the cemented or blister steel and the cast steel of Huntsman is that the first is raw and non-homogeneous, simply because it is not fused, but the second, being melted in crucibles, is of uniform quality throughout. More than this is involved, owing to the addition of alloys. The difference in the two steels is a most important one in cutting instruments where particles, mere specks of non-uniform material, would interfere with the keenness and regularity of the edge. The two methods are described on pages 796 and 797 of the SELF-EDUCATOR. But objection was at first made that the cast steel was much harder to work than the shear steel, and moreover Huntsman still preserved the secret which he had laboured so hard and long to learn, and the Sheffield cutlers of that time, whose craft was endangered, refused to buy his steel, and for a long time all he could make was exported to France. Later, the secret of his method, which he had not patented, was stolen, and before he died, at Attercliffe in 1766, the future of cast steel and of Sheffield was assured.

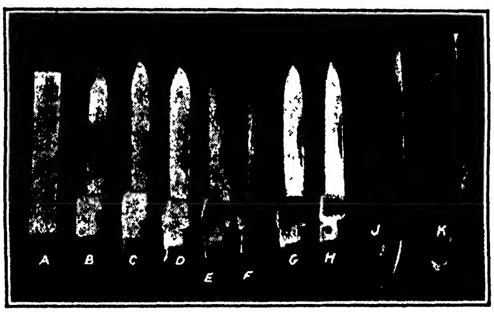
The manufacture of crucible-cast steel and its subsequent grading is tedious and costly. The best products are worth about £60 per ton, and occasionally for special steels higher prices are asked. The inventions of Bessemer and Siemens have given a much cheaper product, costing only one-fifth or one-sixth that of the best crucible steel. The result is that these are used for the cheaper types of cutlery, and the shear steel is reserved exclusively for the better qualities.

The Mushet or self-hardening steel owes its value to the presence of tungsten, and it becomes hard after being heated, and without the quenching in water practised on the carbon steels. It is not used for cutlery, but very extensively for cutting-tools in the engineers' machine-shops, being capable of performing two or three times the work of the ordinary carbon-steel tools.

Steel Grading. All steels are not alike in regard to their suitabilities. There is one steel for razors, and another for saws, and so on through all the range of their services. All the best cutlery steel is made from high-priced Swedish charcoal iron. The bars of nearly pure soft iron are transmuted into blister steel in a converting furnace. Here the skill of the craftsman has in the first place to be exercised in sorting out the products of the furnace. The unsuitability of the converted bars for cutlery consequent on their lack of homogeneity is one of the variables. Another is the difference in their grades or "heats," which ranges from between about ½ per cent. to 1½ per cent. of carbon that is taken up by the bars. The first is a "mild heat" or "spring heat," the last is a "hard heat" or "melting heat." The range of "tempers" between these denotes the amount of carbon present, and the degree of suitability of each for different services. A razor or a knife cannot possibly be made of steel of a "spring" heat; a spring cannot be produced from steel of a "melting" heat. The bars of iron which, when they were inserted in the furnace, could be bent double cold without fracture are now so brittle that they are broken up into short pieces. By means of the aspect of the surfaces the steel-maker forms his judgment of the temper of the steel. In a "spring" heat the outside of the bar only is converted; the interior remains iron, and the bar is said to be full of "sap." The proportion of steel to iron increases through the range of tempers until at the "melting heat," corresponding with about 1½ per cent. of carbon, the crystals of steel extend throughout the bar.

Steel Melting. After having been broken up and sorted, pieces of like quality are melted in pots, and the fusion renders the material homogeneous. That is simply stated, but the details of the operation call for the highest skill of the most experienced workmen. The exact percentage of carbon present is one fact. Homogeneity may not be obtained by mixing hard and soft tempers together, though the ultimate carbon content may be identical. Pieces of blister steel must be used which are already converted to nearly the exact temper required. Or selection may be made of a temper slightly harder than that required, and this may be "let down" by the addition of some slightly milder scrap. All "aired" bars, or those which have not been converted, are rejected, and also "flushed" bars, or those in which the line of demarcation between iron and steel is sharply marked. After these precautions have been taken, the work of melting gives rise to new difficulties. Neglecting accidents to pots, which are not uncommon, the steel suffers if it remains too long in the furnace, or if, on the other hand, for an insufficient period. In the first case it becomes "dead" and brittle; in the second case it is honeycombed.

When the "melt" is ready it is poured or "teemed" into ingots which, when cold, are fractured, and then by the aspect of the fractured surfaces the percentage of carbon is estimated. Between 1 per cent. and 1½ per cent. of carbon, an experienced man is able to judge by fracture of differences in every tenth per cent. present. From this stage the ingots go to the hammer, or to be rolled to be reduced to the dimensions required for the different kinds of cutlery. The ingots are first reheated thoroughly or "soaked" through. In these processes good steel can easily be spoiled, but a bad steel can never be manipulated into one of good quality. And here the failure of the Bessemer and Siemens steel to produce the best cutlery and cutting-tools may be explained. The best steel must be made from iron smelted from ore which contains manganese. In making the Bessemer and Siemens steels, manganese is added in the form of spiegeleisen, or ferro-manganese. But the cutlery steel refuses to take it in that form; it requires to have it in the original iron ore. It takes no count of identical chemical analysis. Steel-making leaves problems unsolved yet.



PARTS OF A PENKNIFE

of cast steel from which blade is forged *b*. Mood of blade—first stage . Mood of blade tang, second stage *d* Smithed blade ready for hardening, third stage *e*. Hardened blade *f*. Tempered blade *g*. Rough ground blade with glazed tang and shoulder *h*. Polished blade—finished *j*. Filed out spring for knife *k*. Hardened and tempered spring for knife

A portion of the ingot is "topped" to remove the hollow or "pipe" which results from shrinkage. It is then, as stated, either hammered or rolled, or both. Almost all manufacturers have hammers, but many send their steel billets out to be rolled by firms who work for the trade. The old tilt-hammer which held the premier place so long is now nearly, though not wholly, superseded by steam or other forging hammers. Whether a billet shall be hammered or rolled depends on the use to which the reduced shapes are to be put. Frequently the first is a stage only to the second.

Varieties of Steel. At the present time all knives and knife-like instruments are not made of the same kind of steel. The demand for cheap cutlery is met by employing Bessemer steel for it. High-class cutlery is made of double-shear steel; that is, as already explained, steel which has been produced by the cementation process, but which has not been cast. The term "double-shear" signifies that it has been bundled and welded and forged twice over, by which process its quality has been rendered homogeneous and its grain finer. Razors and the very best pocket-knives are made of crucible-cast steel. There are good reasons for these differences. Cheap cutlery cannot be made from costly steel; and since the demand for low-priced goods has to be met, that settles the question in favour of Bessemer.

With regard to the blister steel, this is, as already pointed out, a body of iron enclosed in steel. When half a dozen of such bars are welded and drawn down, either under the tilt hammer or between the rolls, the result is an intimate mechanical mixture of iron and steel. It is moderately hard, and favourable to a serviceable cutting edge, while possessing tenacity and elasticity. In the double-shear steel, prepared by taking the single-shear bars, drawing them down, and welding two of them together, the grain is coarser and more irregular than that of Bessemer steel, and the edge is thus more suitable for table use than the finer grain of the Bessemer steel. But razors and surgical instruments, and some of the finest pocket-knives, are made of the crucible steel, because a very slight roughness of the edge would be inconsistent with the character of the work which these instruments have to perform. The fracture of such steel shows a very fine grain, uniform in character, which is still further improved by the hammer blows that are delivered in order to draw down the steel from the rough billet to the required size for the cutting edge. The high price renders the material an exclusive one. It ranges from 25s. to 60s. per hundredweight, from which it will be understood that cheap cutlery cannot be made of good crucible steel.

Machinery *v.* Handcraft. From the preparation of the steel we pass to the manufacture of the principal articles of cutlery. Each different kind of cutting instrument not only entails different methods of working, but it engages the services of large groups of operatives, each of whom performs one bit of detail. Some are simple enough, others call for the exercise of the highest skill gathered by prolonged experience. In making a pair of scissors about thirty processes have to be gone through. In putting together a four-bladed pocket-knife after all the different parts have been prepared, 154 operations have to be performed.

Machinery is now becoming a rival to the acquired skill and deft fingers of the mechanic. It is invading the shops and taking the place of handcraft in two extensive fields—that of forging and of grinding. Recent years have witnessed a large increase in both, especially in the practice of drop-forging, or forging parts in dies or moulds. Many light hammers are now fitted with such dies, in

which blades of various kinds are shaped with a few rapid blows, in place of the slower and more laborious hand methods. Special grinding-machines are also taking the place of hand-grinding for the larger articles.

Table Knives. The steel for these is prepared in bars from an ingot measuring 3 in. square in cross-section. It is first reduced or drawn down under a steam or other hammer, and finished by

2. BLADE-GRINDING
By courtesy of Messrs. Mappin & Webb

rolling into bars measuring about 1 in. wide by ⅛ in. thick. The subsequent methods of forging have been greatly changed in recent years, hand-forging having been displaced in many firms by that done under drop-hammers.

In the first-named the smiths generally work in pairs in a small shop, each man having his own forge. A rolled bar being taken and its end heated, it is drawn down by hand, or under a spring hammer, to form a rough blade, the "mood." After cutting it off, a rod of wrought iron—charcoal iron being the best—is welded on to form the tang and the bolster. The union of the two is the "thumb mark," which is always visible by the brighter or duller colouration of the steel and the iron. The bolster, or shoulder, is that part which keeps the knife off the table, and it is formed by hammering the hot metal in a die or mould. The "tang," or handle portion, is drawn down to its tapered form by hammer blows on the anvil, and the thinner cutting edge is roughly formed by hammering. The maker's name and trade-mark are then stamped on the blade.

This very interesting process of entire forging by hand has now been largely superseded by machine forging from a thick steel bar. It is claimed that blades of equally fine quality and superior toughness can be produced, owing to the amount of hammering which is necessary to reduce the bar to the flat shape of the blank. The incipient bolster is formed under a belt drop-hammer as a projection or enlargement above the blade portion. From this the bolster is stamped, and then the part beyond is lengthened by drawing down to form the tang, which is also often serrated in order that the handle shall grip it thoroughly.

The output by some of the big firms where machine forging is installed is enormous. At the firm where the "Eye-Witness" cutlery is produced, that of Messrs. Needham, Veall, and Tyzack, Ltd., eight or nine power-driven hammers are occupied in stamping knife-blades alone—table, dessert, and carvers. The operators work in pairs, a youth handing the bars of steel, heated at one end, to the forger, who reduces them between the stamps, the "tup" or top half stamp of which is lifted by the belt on the pulley overhead, controlled by the workman. A length of a few inches is drawn down to form the blade, leaving about an inch untouched. A number of blade ends are produced first, and then the inch length is reheated, and a number of bolsters are stamped in separate dies. Another heating is required to form the tang. Gas furnaces are now rapidly superseding the coke fires for heating the steel in these operations.

Knife-making Processes. The cheaper kinds of table cutlery are not even produced by these processes, but are stamped from sheet steel in what is termed a "fly," or open stamp. The tangs are, of course, flat, and the handle is formed in halves, riveted through the flat tang, as in butchers' knives. Some corrective hammering has to be done after the stamping, but the knife does not possess the durability of the forged blade.

The next stage in the manufacture of knife blades is the hardening, followed by tempering. These are two most important operations, on which both the cutting capacity and the elasticity of the knife depend. Every different brand of steel requires some modification in its treatment, and a table-knife which must be able to spring is tempered differently from the more brittle razor, or pocket-knife, or scissors. The knowledge of the minute differences which the smith makes is acquired only by a very lengthy experience.

The hardening is produced by raising the knife blade to a full cherry-red, and plunging it into cold water. This renders the steel "glass hard," and so brittle that a slight rap would break it. Its colour is then a greyish-white. It is put back into the fire and reheated to a light blue colour, and then plunged again into water to impart the proper temper. This statement appears simple in print, but the details have to be most carefully observed. A very few degrees of difference in temperature either above or below the critical and proper stage would influence the temper unfavourably, as also would the presence of any grease in the water or on blade. Neither may the blade be too thin; it is the better to grind away a little excess than to forge too close to size.

Tempering. Tempering is a delicate operation. Danger of cracking exists in addition to the risk of an unsuitable degree of hardness. Blades are dipped into the water either vertically or obliquely, but not flatwise, and they are moved up and down in it until cold. This is done in order to avoid the risk of cracking at a line of demarcation, and also to present the surfaces continually to fresh strata of cold water. It is desirable also to remove the surface scale before tempering. A portion of the surface must be polished in order that the workman may observe the changing tints. This is done by rubbing a bit of grindstone on it. Small articles

like razors and penknives, are heated several at a time in trays, and are removed singly with pliers when the backs come down to a straw colour. Fresh blades are pushed along in the tray to take the places of those removed.

Grinding. Following the tempering comes the rough grinding, still done, as of old, on large natural grit-stones from 4 ft. to 5 ft. in diameter, which are revolved rapidly [2]. The grinder sits on the saddle of a "horsing" coming partly over the stone, and with his feet on the ground, so that he is able, by leaning slightly forward, to press the weight of the upper part of his body on the knife, which he holds on a flat stick, and afterwards on a wooden frame, the stone revolving away from him. Another finish grinding follows on a "whitening" stone, and this is supplemented by "glazing" the blade on a wooden wheel charged with emery, beeswax, and suet, and a final "buffing" on a wooden wheel covered with leather and fine emery. Handling follows, and afterwards a last buffing and inspection [3]. Methods of handling cutlery are dealt with separately in a succeeding article.

The hand-grinding just described is as likely to be largely superseded in the near future as the hand-forging has been. There are now several grinding-machines of wonderful perfection, turning out work of high finish.

Penknives and Pocket-Knives. These are not identical. The first has the blades at opposite ends; in the second they are side by side. Generally, too, the first is of smaller size and lighter than the second. The penknife retains its name, though its original function, that of cutting quill pens, is obsolete. The pocket-knife has more strength in the blades, being required for cutting wood, rope, and for general purposes.

The blades are forged either by hand or in stamps under power hammers. The first-named are forged from bars, the blanks being termed "moods"; the second are stamped from sheets. The latter take a good edge, but they snap more easily in use than those which are hand-forged from the bar.

The blanks are tempered at a dark blue, being made slightly harder than table-knives. The assembling of the blades in the "scales," or sides, and the fitting of the inside division, call for an amount of skill that is only acquired by many years' experience. Every part is prepared by its templates. The steel parts of a penknife which are enclosed in the scales are shown by Fig. 1 suitably named. Although the various sections have to be riveted together finally, they are located and held temporarily with loose pins during the fitting and corrections. First, the metal scales having been prepared from templates and registered together by pins, the edges are filed to outline in the vice guided by a steel pattern. The holes by which the outer coverings of bone or horn are attached are drilled, and the coverings are riveted and afterwards filed to match. Holes are drilled for the insertion of the spring. The springs are drilled and corrected, if necessary, a number being strung on a wire and hardened, not in water, but by "blazing off" in oil, which produces the elasticity required. Many minute operations and adjustments accompany the fitting of the blades into the handle, with proper corrections in relation to the tang and bolster, finishing and polishing, which are too numerous to be detailed.

Patterns. The varieties in knife patterns is astonishing. To name one firm only, that of Messrs. Thomas Turner & Co., of the Suffolk Works, the average number of patterns kept in stock or to order is between 2000 and 3000. At different times no fewer than 10,000 different patterns have been produced there. The explanation is that fashions and tastes change, and that different countries or parts of a country have different tastes and ideas.

Razors. These rank in the highest class of cutlery along with surgical instruments. They are made from crucible-cast steel containing about 1½ per cent. of carbon. The blanks are drawn down on the anvil from bars of about 1 inch square, or they are drop-forged similarly to scissors, are tempered at a straw colour, and are then delivered to the grinders, men of whom a very high grade of skill and experience is demanded. The delicate touch acquired by the hand-grinder is still preferred to any machine-grinding at the final stages. The grinder, without any kind of mechanical guide, is able to maintain the uniformity of thickness absolutely essential, solely by virtue of his highly trained sense of touch. But this final correction is reserved only for a few of the highly skilled men. The rough preliminary grinding is done by those possessing less ability, who only grind the tang and the point, leaving the blade to be dealt with by the more skilled.

The best razors are hollow-ground, a form which permits of re-whetting them without the necessity for re-grinding for many years. At the centre the thickness is little more than that of paper; the cutting edge is thicker, being wedge shaped, and the back is thick to afford the necessary rigidity. The grinding is done first in the longitudinal direction by means of a grooved stone or emery wheel,

3. PASSING BLADES FROM FORGERS AND GRINDERS
By courtesy of Messrs. Mappin & Webb.

after which the blade is ground from back to edge. This is done by means of small cylindrical stones, or wheels, beginning with one that is 6 in. in diameter, and finishing with one of about 2 in. in diameter. The final stages of these operations are the most delicate ones. For if some portion of the edge were ground slightly thinner than others, the razor would be sharpened unequally and become wavy. After the grinding the scratches are removed by "glazing" on a buff or leather-covered wheel, and the blade is finally polished on another.

JOSEPH G. HORNER

The Office and its Equipment. Staff. Copying and Duplicating. Translation Work.

TYPEWRITING AS A BUSINESS

As a means of livelihood, typewriting, usually in conjunction with stenography, is becoming almost the exclusive sphere of women. It is work for which they are particularly fitted. It demands precision, neatness, and attention to detail which seem to constitute too great a strain on the average masculine capacity. When women enter a field in force the position of man becomes gradually untenable, as it seems to be an accepted, though unjust, dictum in our commercial economy that a woman, although fitted for and doing the same work as a man, ought to be content with a very much smaller remuneration. The advent of women into the domain of commercial office work was synchronous with the introduction of the typewriting machine.

Conditions of Employment. The conditions of employment of the woman stenographer and typist are almost as diverse as the offices where she is employed are numerous. The occupation is considered mechanical, and all purely mechanical employments are poorly paid. But a good general education, and the ability to exercise independent judgment in case of ambiguity in the copy, is essential in a thoroughly trustworthy typist, so that the popular conception that typewriting is easy and mechanical is erroneous.

We have heard of girls who professed expert ability both as shorthand writers and as typists accepting positions at 6s. per week. There are certainly some thousands in the City of London today who are earning between 12s. and 16s. a week. But if the average wage of a good typist in a good office could be estimated it would probably be found to be from 25s. to 30s. a week. To attain a higher figure a woman must have exceptional ability and a knowledge of foreign languages, apart from mere proficiency in shorthand and machine manipulation.

The typist aspires to the dignity of proprietress-ship of a typewriting office. The starting of such an office is an important step, and demands caution and circumspection.

A Typewriting Office. The typist ought to have some assured regularity of work, or should be in an exceptionally favourable position for securing it, before she takes an office. Rent and other expenses must be paid whether work comes in or not. The choice of an office is the first consideration. If she have guarantee of regular employment she will naturally instal herself in a position as convenient as possible to the offices or residences of her prospective customers. The large office buildings which in London and other large centres form hives of commercial and professional activity offer the best places for such an establishment. Proximity to possible customers is an essential to constant custom, for the best patrons may be wooed away by an opposition office if the latter be nearer, and therefore more convenient.

The beginner should not consider an office at a higher rent than £50 a year. Indeed, she ought to get one for much less, say £30 or £40, which will be centrally situated and give all the necessary accommodation of two or three rooms. Also, she should not saddle herself with a lease of the office. It is usually possible to secure the premises upon a monthly tenancy.

Equipment. The office, having been secured, must be equipped. The most expensive items are the typewriters themselves. The cash price of the best makes is £22 each. It is possible to buy cheaper machines, but the opinion of the majority of those who make their living by manipulating a typewriter is that, excellent as the cheaper machines may be for occasional and private use, they are not sufficiently strong and reliable to stand the hard wear of constant tapping for eight hours a day throughout 300 days in the year. But the total disbursement need not be made in one payment. All the typewriter companies are prepared to sell their machines upon the hire-purchase system, and the extra price demanded for the accommodation is only 5 per cent. The usual terms of payment on the instalment system of purchase are £2 deposit and £2 per month.

Second-Hand Machines. A word may be said about second-hand typewriters. Occasionally these are more expensive than new machines, owing to the imperfect state of repair. The woman who buys a second-hand typewriter is usually wise to patronise one of the typewriter manufacturing firms, or, if she buys it from an outside dealer, to have the machine examined and certified to be in thoroughly good order by the makers.

It is not our purpose to discriminate between the respective merits of the many typewriters put forward as the best on the market. The purchaser must decide this point from an inspection of the machines themselves or from perusal of descriptive literature, which every manufacturer is only too pleased to supply. But it is a point worthy of note by anyone purchasing a typewriter for use upon many different classes of work that machines of the type of which the Hammond is the best known afford the facility of changing from one style of lettering to another by the mere withdrawal of one type shuttle and the insertion of another, an operation of only a few seconds.

Office Furniture. Besides the typewriter, each operator must be provided with a desk and a chair, the joint cost of which need not exceed 50s. A smaller sum may be made to

suffice by purchasing only a couple of small tables and a few chairs, which may always be bought very cheaply second-hand. Other items of capital expenditure are a carpet or other floor covering, a stock of paper to the value of, say, 20s., some carbon duplicating paper, say, 12s., and the office stationery necessary in any business. The duplicating department, which should be pushed, will entail the purchase of apparatus. The types of machines most satisfactory for such work, together with several labour-saving devices of value to the typist, are discussed in the Business Section on page 1396. The office must be provided with a good dictionary, but one may be purchased for 2s. 6d. If it be found that technical or scientific work comes in regularly and in fair quantity, a technical or scientific dictionary may be required. It is essential to have books of reference to check uncertain orthography. Then, if translation and copying in foreign languages be a department, a set of English-foreign dictionaries must be bought.

Staff. The woman who opens a typewriting bureau will, unless she is fortunate enough to begin with a very good list of regular customers, find that two assistant operators are capable of overtaking all the work she is likely to secure. At least one must be a capable stenographer, as demands will occasionally be made for one to be sent out to write at someone's dictation.

Young girls are often taken into typewriting offices as learners, and the practice enables the proprietress to secure service without salary expense and in return for tuition. Indeed, it is common for learners to pay a premium of £5 5s. to £10 10s. An intelligent learner should in six months acquire expertness in the operation of a typewriter and moderate speed in shorthand, thereby becoming entitled to a salary. She should at the same time have attained a good knowledge of secretarial and general office work. During the first two months of her tuition she will, however, prove of little practical value in regular typewriting work, where experience is essential, and it is uneconomical to trust too much to such assistance.

Copying. The copying of manuscripts is usually the chief business of the office, and is the least remunerative class of work undertaken. Even at the highest scale prices the profits are not large if fair wages be paid to the typists employed. Some expert operators can turn out 1000 words an hour, but this speed can never be maintained for an entire working day. The average amount of work for an eight-hours day is from 4000 to 5000 words, according to the clearness of the copy and its nature. If an operator cannot do this quantity she is not entitled to claim to be a fully qualified typist.

Mimeography. The manifolding of circulars by the aid of a mimeograph or other manifold machine [see page 1400] is far more remunerative than ordinary copying work. An operator can easily take off 200 to 300 copies an hour after the stencil sheet has been typed; and at the regular prices this pays very well indeed. This department should be pushed on every possible occasion, and, by impressing the advantages of mimeographed circulars upon customers, much work which would otherwise issue in printer's type may be secured for the typewriting office.

The ribbon process duplicator, an excellent device now considerably used, is a machine by means of which letters intended for multiple reproduction are set up in metal typewriter type and printed through a wide typewriter ribbon. The effect is, of course, to get the ribbon impression of the typewriter, and not the mere imitation, as is the case with the reproductions made with the stencil duplicators.

Foreign Translation. It is desirable that translations to and from French and German should be executed in the office either by the principal or by a qualified assistant. It is, however, unusual to translate other foreign languages in the office, but to send them to regular translation bureaux. Many typewriting offices whose proprietors profess to do such work in the office merely send it to a translation bureau. The usual practice is that the translation bureau allows a discount of 25 per cent. from usual retail price, and this proportion represents the profit of the typewriting office.

Shorthand Work. The shorthand department of a typewriting office is another fairly lucrative branch, if prices recognised as standard be maintained. The work is paid for by time, and the quantity possible in a given time depends upon the speed of the dictator rather than upon the ability of the stenographer. The assistant sent to record dictation should always be able to work up to the limit of the customer's speed of speaking, for nothing dissatisfies a business man more than a stenographer for whom he has to wait. [See SHORTHAND.]

Dictating Machines. Another class of work has lately entered into practice. This is the dictation into the phonograph or graphophone by professional or business men. By its agency the need for the presence of a shorthand writer by the side of the dictator is obviated, and this is no small recommendation. We believe that there is a field for enterprise in taking up the typing of matter thus recorded. Information regarding the dictating machine is given in page 1402.

Business Methods. Little remains to be said about the methods of business. Neat circulars, intimating the opening of an office, and indicating the scope of the work undertaken, ought, of course, to be issued to likely customers. If the office be in a large office building, good may be done by making regular morning calls upon every individual or firm likely to have work. Accounts should be rendered whenever any work is done, or, if to regular customers, weekly. Work is often secured by advertising in literary papers. Authors' work is usually desirable, being straightforward and very often in good batches.

W. B. ROBERTSON

TYPEWRITING CONCLUDED—END OF GROUP 24

Monomial Factors. Factors by Grouping Terms. Use of Formulæ Difference of Two Squares. Sum or Difference of Two Cubes.

ALGEBRAIC FACTORS

FACTORS

53. We have already considered how the product of two or more algebraical expressions is formed. In simple cases we can do the converse of this; that is, when we are given the product we can find the factors which were multiplied together to make that product. This is called the *resolution into factors* of the product.

54. Monomial Factors. When each term of an expression contains a common factor we can divide the whole expression by that factor.

Example 1. Every term of $2x^3 - 4x^2 + 6x$ is divisible by $2x$.

Thus,

$$2x^3 - 4x^2 + 6x = 2x\,(x^2 - 2x + 3).$$

Example 2.

$$34a^2x^4 + 51a^4x^2 = 17a^2x^2\,(2x^2 + 3a^2).$$

EXAMPLES 11

Resolve into factors

1. $x^3 + 6x$.
2. $a^2 + ab + ac$.
3. $11a^2b^2c - 33abc^3$.
4. $3x^4 - 2x^2y^2 + xy^3$.
5. $5y^4 - 20xy^3$.
6. $39xy^2z + 45yz^2$.
7. $6ax^3 + 4a^2x - 8a^3$.
8. $68 - 51x^2$.
9. $114a^4bc^2 + 95ab^2c^2$.

55. Factors Found by Grouping the Terms. Many expressions can be resolved into factors by a suitable grouping of the terms. At present we shall only notice the case where one of the letters involved always occurs in the *same power*. Generally, if we group together the terms which contain that letter, a factor of the expression becomes evident.

Example 1. Resolve into factors $ab + b^2 + bc + ac$.

Here, we notice that when a occurs in any term it is always of the *first* degree. We therefore group together the terms which contain a, thus $(ab + ac) + b^2 + bc$. We now take out the factor a from the first two terms, and the factor b from the last two, obtaining $a\,(b + c) + b\,(b + c)$. It now becomes obvious that $(b + c)$ is a factor of the whole expression. If, in fact, we suppose for a moment that $(b + c)$ has the value x, the expression would be $ax + bx$; and this is of the same *form* as the examples considered in Art. **54**, so that its factors are $x\,(a + b)$. That is, the given expression is equal to $(b + c)\,(a + b)$.

Hence, our working appears as follows,

$$\begin{aligned} &ab + b^2 + bc + ac \\ &= a\,(b + c) + b\,(b + c) \\ &= (b + c)\,(a + b) \ \underline{Ans.} \end{aligned}$$

Notice that the above is not the *only* way of grouping the terms. We should have found the factors just as easily by grouping together the terms bc and ac, since they contain c in the first degree only, and c occurs in no other term.

Example 2. Resolve into factors

$$a^2 + a\,(b + c + d) + d\,(b + c).$$

Here d only occurs in the *first* power. Therefore we have

$$\begin{aligned} &(ad + bd + cd) + (a^2 + ab + ac) \\ &= d\,(a + b + c) + a\,(a + b + c) \\ &= (a + b + c)\,(a + d) \ \underline{Ans.} \end{aligned}$$

The first line of the above working is not really necessary. The student should find no difficulty in at once writing the given expression in the form $d\,(a + b + c) + a\,(a + b + c)$.

Example 3. Resolve into factors $a^2b^2c^2 - b^2c - a^2c + 1$.

Given expression

$= a^2c\,(b^2c - 1) - (b^2c - 1)$

[by taking together the first and third terms. Note that in putting $-\,b^2c + 1$ into brackets we change the signs (Art. **19**); in reality we are taking out the factor -1.]

$= (b^2c - 1)\,(a^2c - 1)$ $\underline{Ans.}$

EXAMPLES 12

Resolve into factors

1. $x^2 + ax + bx + ab$.
2. $ab^2 + b^2 + a + 1$.
3. $ax^2 - (a + b)\,xy + by^2$.
4. $ac + bc - ad - bd$.
5. $x^2y^2 - 2x^2 + 2y^2 - 4$.
6. $ax - 2by + 2ay - bx$.
7. $x^3 - ax^2 + x - a$.
8. $ax - ayz + bcx - bcyz$.
9. $x^4 + 2x^2\,(y^2 + z^2) + 4y^2z^2$.
10. $x^3y^3 + 2ay^3 - 3ax^3 - 6a^2$.

56. Factors by Comparison with Formulæ. In Art. **31** and those immediately following we obtained several *general* results in multiplication. If a given expression is of the *same form* as any of these results we can write down its factors by inspection. For example, in Art. **32**, we showed that

$$(x + a)^2 = x^2 + 2ax + a^2.$$

If, then, we have an expression which consists of the square of one quantity *plus* the square of another, together with twice the product of the two quantities, we know at once that the expression is equal to the square of the sum of the two quantities.

Example 1. The expression $x^2 + 4ax + 4a^2$ consists of the square of x, the square of $2a$, and twice the product of x and $2a$. It follows that the expression is the square of $x + 2a$. Thus,

$$x^2 + 4ax + 4a^2 = (x + 2a)^2.$$

Example 2. Resolve $4a^2 - 12ab + 9b^2$ into factors.

In this case $4a^2$ is the square of $2a$, $9b^2$ is the square of $(-3b)$, and $-12ab$ is twice the product of $2a$ and $(-3b)$. Hence $4a^2 - 12ab + 9b^2$ is the square of the sum of $2a$ and $-3b$, or

$$4a^2 - 12ab + 9b^2 = (2a - 3b)^2.$$

If the terms have a common factor, this factor must be removed first, as in Art. **54**.

Example 3. Resolve $12a^2b^2 - 3a^3b - 12ab^3$ into factors.

Here, $3ab$ is a factor of every term. Therefore we have

$$\begin{aligned} 12a^2b^2 - 3a^3b - 12ab^3 &= 3ab\,(4ab - a^2 - 4b^2) \\ &= -3ab\,(a^2 - 4ab + 4b^2) \\ &= -3ab\,(a - 2b)^2. \end{aligned}$$

EXAMPLES 13

Resolve into factors

1. $x^2 + 4x + 4$.
2. $y^2 - 6y + 9$.
3. $25a^2 - 20ab + 4b^2$.
4. $-6a^2 - 3a^4 - 3$.
5. $4x^4 + 8x^2y + 4y^2$.
6. $2a^2x^2 + 2a^2b^2 + 4a^2bx$.
7. $(x + y)^2 + z^2 + 2z\,(x + y)$.
8. $(a + b)^2 - c\,(a + b) + \frac{1}{4}c^2$.

57. In Art. **31** we found that

$$(x + a)\,(x + b) = x^2 + (a + b)\,x + ab.$$

From this it is evident that if such an expression as $x^2 + 5x + 6$ is the product of the two binomial factors $x + a$, $x + b$, then $a + b$ must equal 5 and ab must equal 6. That is, we have to find two numbers whose sum is 5 and whose product is 6. These are easily seen to be 2 and 3. Hence,

$$x^2 + 5x + 6 = (x + 2)\,(x + 3).$$

Example 1. Find the factors of $x^2 + 14x + 24$.

Here we require two numbers whose sum is 14 and whose product is 24. We examine, then, pairs of numbers whose product is 24, viz., 24 and 1, 12 and 2, and so on, until we find the pair whose sum is 14. Therefore,

$$x^2 + 14x + 24 = (x + 12)\,(x + 2) \quad \underline{Ans.}$$

Example 2. Find the factors of $x^2 - x - 30$.

We require two numbers whose sum is -1 and whose product is -30. Since their product is *minus* 30, the numbers must be of opposite signs. Hence, their algebraical sum will be found by taking one number from the other and prefixing the sign of the greater of the two [Art. **14**]. We have thus, in effect, to find two numbers whose product is 30 and whose *difference* is 1. Proceeding as in Ex. 1 we find the numbers are 5 and 6. It is now easily seen that the numbers whose product is -30 and sum is -1 are 5 and -6. Hence

$$x^2 - x - 30 = (x + 5)\,(x - 6) \quad \underline{Ans.}$$

Example 3. Find the factors of $a^2 - 7ab + 12b^2$.

The introduction of the letter b does not cause any fresh difficulty. We have to find two quantities whose product is $12b^2$ and whose sum is $-7b$. Since the product is to be positive, the two quantities must be either *both* positive or *both* negative [Art. **21**]. Since their sum is to be *negative*, they must both be negative. Evidently, then, the quantities required are $-3b$ and $-4b$. Hence,

$$a^2 - 7ab + 12b^2 = (a - 3b)\,(a - 4b) \quad \underline{Ans.}$$

NOTE. If the product of the required quantities is at all large, it is easier to find them if we first put the product into *prime* factors. We have then to separate these factors into two groups, and test whether the factors of these groups form the quantities we require. For example, suppose we want two numbers whose product is 540 and whose difference is 12. Put 540 into its prime factors, 2 . 2 . 3 . 3 . 3 . 5. Then, by repeated trials, we eventually find that 2 . 3 . 3 and 2 . 3 . 5 (*i.e.*, 18 and 30) are the two numbers whose difference is 12.

EXAMPLES 14

Resolve into factors

1. $x^2 + 3x + 2$.
2. $y^2 - 8y + 15$.
3. $x^2 - 3x - 28$.
4. $a^2 + 14a - 51$.
5. $y^2 - y - 240$.
6. $x^2 - 25x - 150$.
7. $y^2 + 51y + 50$.
8. $a^2 - 17ab + 42b^2$.
9. $x^2 - xy - 182y^2$.
10. $x^2 - 27xy + 176y^2$.
11. $2x^2 + 24xy - 90y^2$.
12. $3a^2 - 6ab - 504b^2$

58. In the last article the highest power in the expression to be factorised had unity for its coefficient. We have now to consider the case in which the coefficient is not unity. Suppose we form the product of the two binomials $2x - 3$ and $3x - 4$. Multiplying both terms of the first by each term of the second, we obtain

$$\begin{aligned} (2x - 3)\,(3x - 4) &= 6x^2 - 9x - 8x + 12 \\ &= 6x^2 - 17x + 12. \end{aligned}$$

Now, in the converse operation, we are given the expression $6x^2 - 17x + 12$ and have to get back to the factors $2x - 3$ and $3x - 4$. This would be very simple *if we knew that the term* $-17x$ *had been obtained from* $-9x$ *and* $-8x$, and not from any other pair of terms, such as $-20x$ and $+3x$. Our first aim, then, must be to find these two numbers 9 and 8. This is easily done if we notice that their product, 72, is the same as the product of the other two coefficients, 6 and 12, in the expression $6x^2 - 17x + 12$; for we have only to find two numbers whose product is 72 and whose sum is 17.

Hence, to factorise the expression $6x^2 - 17x + 12$, *the sign of the third term being* +, we

(i.) Multiply the first and last coefficients, 6 and 12, obtaining 72.

(ii.) Find two numbers whose product is 72 and whose *sum* (since the sign of the third term is +) is 17. These are easily seen to be 9 and 8.

(iii.) Separate the term $-17x$ into the two terms $-9x$ and $-8x$, thus obtaining $6x^2 - 9x - 8x + 12$.

We can now take a common factor $3x$ from the first two terms, and a common factor -4 from the last two; and the rest of the process is like that of Art. **55**. Thus

$$\begin{aligned} 6x^2 - 17x + 12 &= 6x^2 - 9x - 8x + 12 \\ &= 3x\,(2x - 3) - 4\,(2x - 3) \\ &= (2x - 3)\,(3x - 4). \end{aligned}$$

59. Again, we have

$$(2x-3)(3x+4) = 6x^2 - 9x + 8x - 12$$
$$= 6x^2 - x - 12.$$

and, exactly as before, the chief point is to find that $-x$ was obtained from $-9x + 8x$. Now, since these two terms are of opposite sign, they are combined by *subtracting* the absolute values of their coefficients.

Hence, to factorise the expression $6x^2 - x - 12$, *the sign of the third term being* $-$, we

(i.) Multiply the first and last coefficients, 6 and 12, obtaining 72.

(ii.) Find two numbers whose product is 72 and whose *difference* (since the sign of the third term is $-$) is 1, the coefficient of x. The two numbers are 9 and 8.

(iii.) Since the middle term of the given expression is *minus*, we put the sign $-$ before the greater of the two numbers, thus separating the middle term into the two terms $-9x$ and $+8x$. The rest of the process is the same as before.

$$6x^2 - x - 12 = 6x^2 - 9x + 8x - 12$$
$$= 3x(2x-3) + 4(2x-3)$$
$$= (2x-3)(3x+4).$$

Example 1. Find the factors of $10x^2 + 37x + 7$.

Here, we require two numbers whose product is 10×7, or 70, and whose *sum* (since the sign of the third term is $+$) is 37. These are easily seen to be 2 and 35. Therefore

$$10x^2 + 37x + 7 = 10x^2 + 2x + 35x + 7$$
$$= 2x(5x+1) + 7(5x+1).$$
$$= (5x+1)(2x+7).$$

Example 2. Find the factors of $4x^2 + 3xy - 27y^2$.

We require two numbers whose product is 4×27, and whose *difference* (since the sign of the third term is $-$) is 3. These are found to be 12 and 9. [See Note, Art. 57.] The middle term is *plus* $3xy$, so we take $+12xy$ and $-9xy$. Thus,

$$4x^2 + 3xy - 27y^2 = 4x^2 + 12xy - 9xy - 27y^2.$$
$$= 4x(x+3y) - 9y(x+3y)$$
$$= (x+3y)(4x-9y).$$

EXAMPLES 15

Put into factors

1. $2x^2 - 5x + 2$.	5. $132x^2 - 13x - 2$.
2. $6x^2 + 19x + 15$.	6. $9x^2 + 142x - 32$.
3. $21x^2 - 5xy - 4y^2$.	7. $17x^2 - 88xy + 15y^2$
4. $26x^2 + 87xy - 14y^2$.	8. $12x^3 - 28x^2 + 8x$.

9. $110x^3y + 58x^2y^2 - 24xy^3$.

10. $8x^2 - 34x + 8$.

60. In Article **33** it was proved that

$$x^2 - a^2 = (x+a)(x-a).$$

Thus, if an expression can be written as the difference of the squares of two quantities, its factors consist of the sum of the two quantities and the difference of the two quantities.

Example 1. Find the factors of $16x^2 - 25y^2$.

The expression is the difference of the squares of $4x$ and $5y$. Hence

$$16x^2 - 25y^2 = (4x+5y)(4x-5y).$$

Example 2. Put into factors $8x^3y - 2xy$.

$$8x^3y - 2xy = 2xy(4x^2 - 1)$$
$$= 2xy\{(2x)^2 - (1)^2\}$$
$$= 2xy(2x+1)(2x-1).$$

Example 3. Put into factors $(3x + y - z)^2 - (x - y + z)^2$.

Given expression

$$= \{(3x+y-z) + (x-y+z)\}\{(3x+y-z) - (x-y+z)\}$$
$$= (3x+y-z+x-y+z)(3x+y-z-x+y-z)$$
$$= 4x(2x+2y-2z)$$
$$= 8x(x+y-z).$$

In some cases a slight modification is necessary before the two squares become evident.

Example 4. Find the factors of $x^4 - 21x^2y^2 + 4y^4$.

Here, x^4 is the square of x^2 and $4y^4$ is the square of $2y^2$. Also, if we square the expression $(x^2 + 2y^2)$ we obtain $x^4 + 4x^2y^2 + 4y^4$. Now, to make this identical with the given expression we must subtract $25x^2y^2$. Hence,

$$x^4 - 21x^2y^2 + 4y^4 = (x^2 + 2y^2)^2 - 25x^2y^2$$
$$= \{(x^2 + 2y^2) + (5xy)\}\{(x^2 + 2y^2) - (5xy)\}$$
$$= (x^2 + 5xy + 2y^2)(x^2 - 5xy + 2y^2).$$

Example 5. Resolve into factors $4x^4 - 28x^2 + 9$.

If, in this case, we take $(2x^2 + 3)^2$ we obtain $4x^4 + 12x^2 + 9$, and have to subtract $12x^2 + 28x^2$, *i.e.*, $40x^2$, to make it equal to the given expression. But $40x^2$ is not a perfect square, so that this transformation does not help us. If, however, we try $(2x^2 - 3)^2$, we still obtain $4x^4$ and $+9$, but the sign of the $12x^2$ becomes *minus*, and we have then to subtract $16x^2$, which *is* a perfect square. Hence,

$$4x^4 - 28x^2 + 9 = (2x^2 - 3)^2 - 16x^2$$
$$= (2x^2 + 4x - 3)(2x^2 - 4x - 3).$$

EXAMPLES 16

Resolve into factors

1. $x^2 - 121$.	4. $a^2b^2 - 49$.
2. $a^2 - 16b^2$.	5. $36 - x^2y^2$.
3. $1 - 25y^2$.	6. $32x^2 - 18y^8$.

7. $(2x + 5y)^2 - (x - 3y)^2$.

8. $(a + 2b)^2 - (a - 2b)^2$.

9. $9(a + b)^2 - (a - b)^2$.

10. $a^4 - 6a^2 + 25$. 11. $x^4 - 40x^2y^2 + 4y^4$.

12. $y^4 - 6y^2 + 1$.

61. By multiplication we find that

$$(x+a)(x^2 - ax + a^2) = x^3 + a^3$$

and that

$$(x-a)(x^2 + ax + a^2) = x^3 - a^3.$$

These formulæ enable us to factorise expressions which are either the sum or the difference of two cubes.

Example 1. Resolve into factors $8a^3 + 27b^3$.

This is the *sum* of the cubes of $2a$ and $3b$. The expression is therefore divisible by the *sum* of $2a$ and $3b$. The terms of the other factor are the square of $2a$, the square of $3b$, and the product of $2a$ and $3b$, the product term being negative. Thus

$$8a^3 + 27b^3 = (2a + 3b)(4a^2 - 6ab + 9b^2).$$

Example 2. Resolve into factors $27x^3 - \dfrac{8}{x^3}$.

This is the *difference* of the cubes of $3x$ and $\dfrac{2}{x}$, and is therefore divisible by the *difference*

of $3x$ and $\frac{2}{x}$. The other factor is formed in the same way as before, but the product term is positive. Hence,

$$27x^3 - \frac{8}{x^3} = \left(3x - \frac{2}{x}\right)\left(9x^2 + 6 + \frac{4}{x^2}\right).$$

EXAMPLES 17

Resolve into factors

1. $a^3 + 125b^3$.
2. $27a^3 - 64b^3$.
3. $x^6 - 8y^6$.
4. $2x^5 + 16x^2y^3$.
5. $(a + 2b)^3 - a^3$.
6. $8a^3 - \frac{64}{b^3}$.
7. $(a - 2b)^3 - (b - 2a)^3$.
8. $\frac{x^3}{343} - \frac{27}{x^3}$.
9. $\frac{a^3b^3}{1000} + 125$.

62. By division, Art. **42**, we proved that

$$a^3 + b^3 + c^3 - 3abc = (a + b + c)(a^2 + b^2 + c^2 - bc - ca - ab).$$

Therefore, when an expression consists of the sum of the cubes of three quantities diminished by three times their product, it can be resolved into factors by means of this formula.

Example. Resolve $8x^3 - y^3 + 6xy + 1$ into factors.

Here $8x^3$ is the cube of $2x$, $-y^3$ is the cube of $-y$, 1 is the cube of 1. Also, 3 times the product of $2x, -y$, and 1 is $-6xy$. Therefore,

$$8x^3 - y^3 + 6xy + 1$$
$$= (2x)^3 + (-y)^3 + 1^3 - 3(2x)(-y).$$
$$= (2x - y + 1)(4x^2 + y^2 + 1 + y - 2x + 2xy).$$

Answers to Algebra

EXAMPLES 8

1. $x=5, y=3$.
2. $x=3, y=-4$.
3. $x=3, y=2$.
4. $x=3\frac{3}{4}, y=\frac{3}{4}$.
5. $x=y=5$.
6. $x=4, y=8$.

7. Since $\frac{x}{15} + \frac{y}{12} = 1$, we have $4x + 5y = 60$.

And since $\frac{x}{3} - \frac{y}{4} = 1$, we have $4x - 3y = 12$

Hence, $x=7\frac{1}{2}, y=6$.

8. Multiply first equation by 10, giving $5x - 5y - 6x + y = 5$, or $x + 4y = -5$. Multiply second equation by 6, $2x - 3y = 12$. Hence, $x=3, y=-2$.

9. Solve for $\frac{1}{x}$ and $\frac{1}{y}$ obtaining $\frac{1}{x}$ $\frac{1}{2}$ $= -1$. So that $x=2, y=-1$.

10. Solve for x and $\frac{1}{y}$. Solution is $x = 4$, $y=1$.

11. $x=y=a^2-b$. **12.** $x=a, y=b$.

13. Add the three equations together, $2x + 2y + 2z = 20$. Therefore, $x + y + z = 10$. Subtract each equation in turn from this, and we obtain $x=3, y=5, z=2$.

14. $x=-3, y=1, z=3$.

15. Add first two equations, giving $\frac{2}{x} = 4$. Hence, $x=\frac{1}{2}$. Substitute in second and third equations, and we get $\frac{1}{y} - \frac{1}{z} = -2$, and $\frac{1}{y} + \frac{1}{z} = 10$. Whence $y=\frac{1}{4}, z=\frac{1}{6}$.

EXAMPLES 9

1. Let x = greater number. Then, since their difference is 7, the less number is $x - 7$. Therefore $x + x - 7 = 63$, so that $x = 35$. Hence the required numbers are 35 and 28.

2. Let x = the number. When multiplied by 3, the product exceeds 18 by $3x - 18$. Also, the original number is less than 18 by $18 - x$. Hence $3x - 18 = 18 - x$, which gives $x = 9$.

3. Let x = the greater part. Then $39 - x$ = the less. Twice the greater is $2x$, and three times the less is $3(39 - x)$. Hence $2x + 2 = 3(39 - x)$, so that $x = 23$. The two parts are therefore 23 and 16.

4 Let x = the third part. Then, the second part is 3 more than thrice x, *i.e.*, $3x + 3$ = the second part. The first part = twice the second $= 6x + 6$. The sum of the three parts is 69, so that $x + 3x + 3 + 6x + 6 = 69$; whence $x = 6$. Thus, the third part is 6; the second part is $3x + 3$, or 21; and the first part is twice 21, or 42.

5. Let $2x$ = the number. Then, one more than its double is $4x + 1$, and one less than its half is $x - 1$. Its square is $4x^2$. Hence $(4x + 1)(x - 1) = 4x^2 - 10$. Therefore $4x^2 - 3x - 1 = 4x^2 - 10$, or $3x = 9$, and $x = 3$. The required number is twice x, *i.e.*, 6.

6. Let x years = the son's present age. Then $3x$ years = the father's age. In 12 years the father will be $3x + 12$, and the son will be $x + 12$. Hence $3x + 12 = 2(x + 12)$, which gives $x = 12$. Therefore the son's age is 12 years, and the father's is 36.

7. Let x years = age of eldest. Then $x - 5$ = age of second, and $x - 5 - 3$, or $x - 8$ = age of youngest. Therefore $x + x - 5 + x - 8 = 47$, whence $x = 20$. Required ages are 20 years, 15 years, 12 years.

8. Let x pounds = amount A has. Then, since A and B have £39 between them, $39 - x$ = number of pounds B has. Similarly, since A and C have £31 between them, $31 - x$ = number of pounds C has. But B and C together have £26. Therefore $39 - x + 31 - x = 26$, whence $x = 22$. Thus, A has £22, B has £17, and C has £9.

9. Let x = number of crowns. Then $81 - x$ = number of shillings. The total value in sixpences $= 10x + 2(81 - x)$. Again, the value in sixpences of x florins and $(81 - x)$ half-crowns $= 4x + 5(81 - x)$. Therefore $10x + 2(81 - x) = 4x + 5(81 - x)$, whence $x = 27$. Thus, there are 27 crowns and 54 shillings.

10. Let x = cost of an orange, in pence. Twelve oranges cost $12x$ pence, *i.e.*, $(12x - 10)$ pence over 10d. Similarly, 20 oranges cost $(30 - 20x)$ pence under half-a-crown. Therefore

$12x - 10 = 30 - 20x$. Hence $x = 1\frac{1}{4}$. Since an orange costs $1\frac{1}{4}$d., the number which can be bought for 5s. is 5s. ÷ $1\frac{1}{4}$d., *i e*, 48.

11. Since 4 sides of the one carpet measure 16 feet more than 4 sides of the other, the side of the first is 4 feet longer than the side of the second. Therefore if x feet = side of smaller carpet, then $x + 4$ = side of the other. Their areas will be x^2 square feet and $(x+4)^2$ square feet. Hence $(x + 4)^2 - x^2 = 64$; which gives $x = 6$. The sides of the two carpets are 6 feet and 10 feet.

12. Let x = number of sovereigns. Then $3x$ = number of half-crowns, and $26 - x - 3x$, or $26 - 4x$ = number of shillings. The total value is £6. Hence, expressing everything in sixpences, we have $40x + 15x + 2\ (26 - 4x) = 240$, whence $x = 4$. Thus, there are 4 sovereigns, 12 half-crowns, and 10 shillings.

13. Let x = number of shillings A has. If he gives B ten shillings, A has $(x - 10)$ shillings left. This is three times as much as B now has, *i.e.*, B now has $\frac{x-10}{3}$ shillings. Therefore B originally had 10s. less than this, *i.e.*, $\frac{x-10}{3} - 10$. If, then, B gave A five shillings, A would have $(x + 5)$ shillings and B would have $\frac{x-10}{3}$ 10 − 5. Therefore, since this makes A have 4 times as much as B, $x + 5 = 4\left(\frac{x-10}{3} - 15\right)$. Multiply by 3, and remove brackets, $3x + 15 = 4x - 40 - 180$, so that $x = 235$. Thus A has 235s, or £11 15s., and B has $\frac{235-10}{3} - 10 = 65$s. = £3 5s.

14. Let x = the middle number. The number before x is $x - 1$, and the number following x is $x + 1$. The product of these three is to be 5 less than the cube of x. Hence $x\ (x - 1)\ (x + 1) = x^3 - 5$, or $x^3 - x = x^3 - 5$. Therefore $x = 5$, and the required numbers are 4, 5, 6.

15. The number is *increased* by reversing the digits, therefore the units' digit is the greater. Hence, let x = the tens' digit. Then $3x$ = the units' digit, and the number is $10x + 3x$, or $13x$. If the digits be reversed the number is $30x + x$, or $31x$. Therefore $31x - 26x = 10$. Thus $x = 2$, and the required number is 13×2, or 26.

Examples 10

1. Let x = the greater number, and y = the less. Then $x + y + 2 = 5\ (x - y)$ and $3x - 4y = 7$. The solution of these equations gives $x = 17$ and $y = 11$.

2. Let x years = the father's age; y = the son's. In another year the father will be $(x + 1)$ years and the son $(y + 1)$ years. Therefore $x + 1 = 4\ (y + 1)$. Two years ago the father was $x - 2$; in another 3 years the son will be $y + 3$. Therefore $x - 2 = 3\ (y + 3)$. From these two equations we get x, the father's age, = 35 years, and y, the son's, = 8 years.

3. Let x = the digit in the tens' place, and y = the digit in the units' place. Then the number is $10x + y$. This exceeds 5 times the sum of the digits by 7. Hence $10x + y - 7 = 5\ (x + y)$. Again, $10y - x$ is the number formed by reversing the digits, and this is 9 less than the original number. Hence $(10x + y) - (10y + x) = 9$. From these we get $x = 3$, $y = 2$, so that the required number is 32.

4. Let £x = amount A has. Then $2x$ = amount C has. Let £y = amount D has. Then $3y$ = amount B has. Total is £100, so that $x + 2x + y + 3y = 100$, *i.e.*, $3x + 4y = 100$. Again, C and D together have $2x + y$. This is £$2\frac{1}{2}$ more than B. Hence $2x + y = 3y + 2\frac{1}{2}$, or $4x - 4y = 5$. Solving the equations, we get $x = 15$, $y = 13\frac{3}{4}$. Thus A has £15, B has $3 \times$ £$13\frac{3}{4}$, or £41 5s., C has £30, and D has £13 15s.

5. Let x years = elder son's age, y years = younger's age. In 2 years the elder will be $x + 2$. Therefore the father will then be $3\ (x + 2)$. Similarly, the younger will be $y + 2$, and the father will therefore be $5\ (y + 2)$. Hence $3\ (x + 2) = 5\ (y + 2)$, or $3x - 5y = 4$. Again, since in 2 years' time the father will be $3\ (x + 2)$, his present age is $3\ (x + 2) - 2$, or $3x + 4$. Therefore, since in 23 years his age equals the sum of his sons' ages, we have $3x + 4 + 23 = x + 23 + y + 23$, or $2x - y = 19$. Solving the two equations, we get $x = 13$, $y = 7$. Thus, the father's present age is $3x + 4$, *i.e.*, 43 years, the elder son is 13, and the younger 7.

6. Let x = number of miles A walks per hour, and y = number B walks per hour. In 8 hours A walks $8x$ miles, and in 5 hours B walks $5y$ miles. Therefore $8x - 5y = 8$. Again, in 9 hours B walks $9y$ miles, and in 10 hours A walks $10x$ miles. Therefore $9y - 10x = 1$, whence $x = 3\frac{1}{2}$, $y = 4$, and the required rates are A, $3\frac{1}{2}$ miles per hour; B, 4 miles per hour.

7. Let x = number of shillings in the amount A has, and y = number of shillings in the amount B has. Therefore $x + y = 21$. Now B has $12y$ pence. If, then, A gives B $12y$ shillings, B will then have $y + 12y$, or $13y$ shillings; A will have $x - 12y$ shillings. Hence $13y - (x - 12y) = 5$, or $25y - x = 5$. These equations give, by addition, $y = 1$. Therefore B has 1s., and, consequently, A has 20s.

8. Let x = number of miles A goes per hour, and y = number B goes. To go 60 miles A will take $\frac{60}{x}$ hours, and B will take $\frac{60}{}$. Hence $\frac{60}{x} - \frac{60}{y} = 5$. Again, if A's rate had been $2x$ miles per hour, he would take $\frac{60}{2x}$, *i.e.*, $\frac{30}{x}$ hours to go 60 miles. Hence $\frac{60}{y} - \frac{30}{x} = 5$. Adding these equations, we get $\frac{30}{}$ = 10. Therefore x = 3 miles per hour. By substitution $\frac{60}{y}$ 15, or y = 4 miles per hour.

H. J. ALLPORT

ABSOLUTE DESPOT OF FRANCE—LOUIS XIV.

BY HIS PERSONAL SWAY LOUIS XIV. RAISED HIS COUNTRY TO A GREAT POSITION IN EUROPE, THOUGH THE TIDE OF DISASTER WHICH LED TO THE REVOLUTION BEGAN TO FLOW BEFORE HIS DEATH

The Influence of Companions in Inducing Slackness or in Stimulating Effort and Ennobling Character

THE CHOICE OF COMPANIONS

The importance of a wise choice of companions may be inferred from the fact that every book or article offering advice to young people contains a chapter or a paragraph on the subject. And no wonder it is so; for if all the men who have attained success could be questioned respecting the influences which have helped them, a majority, probably, would give a high place to the companionships they joined at one or other stage in their career. As for the failures, rightly or wrongly, five-sixths of them would make bad companionships an excuse for their degeneracy. It may be that on each side, good and bad, the influence of companionship is somewhat over-stated, for what we become, whether it is favourable or unfavourable, depends, as a rule, primarily, on inherent powers and tendencies, which companionships, and other surroundings and opportunities, can only retard or develop. But such familiar influences, though secondary, are still very potent, and fully warrant the attention they receive.

So far as bad companionship is concerned, it may be passed by here with the barest reference, since the presumption is that anyone who has sense enough to be a student of such a publication as the SELF-EDUCATOR will also have sense enough to see the folly of association with people who are vicious, gross, or lacking in ideality. It is only against more insidious temptations towards the rocks that the warning cone needs be raised.

Perhaps, however, one phase of bad companionship may be mentioned with advantage. Someone may ask whether it is not well that every man should have knowledge, by personal observation, of the darker and rougher features of life and character. Take two groups of workers as instances—the average sailor and the average navvy. Nowhere is the mixture of manliness with coarseness seen more strongly than in these fine fellows. A firm sense of duty and a splendid capacity for heroism often combine in them with a roughness that borders on vice, and easily merges into it. Their acts may shine with the glow of chivalry when they are tested to the uttermost, though much of their ordinary talk is outside the pale of decency. Nobody understands better than they the full quality of manliness.

And the same curious contrasts may be found up and down the whole scale of the world's rough workers. Should we not know such men, and indeed all men? Ought we not to observe personally what is called "life"? The reply is "Yes; we should observe it when we are able to judge it impersonally and unharmed, but we can never know it through bad companionship." Whether a knowledge of "life" soils us, or strengthens us in wisdom and human tenderness, depends on the spirit in which we approach it; and, invariably, seeing it through bad companionship is seeing it in the manner that soils the soul.

Turning from the companionships that issue their own warnings because they are gross, we find ourselves among those which are dangerous because they are more insidious and give forth no warnings, but, indeed, appeal to the side of our nature that is weak rather than wicked.

There is, for example, the beckoning playful influence which leads us pleasantly down the gentle slope of recreation into the Valley of Ease. It is so self-complimentary to think we are hard worked and require more leisure, and that we are being really virtuous when we plan, with agreeable companions, delightful methods of spending our time. Within reasonable limits, of course, this relaxation is wise, but what is needed from us normally is resolute, strong endeavour that will establish us in our right place in the world; and the companions are enemies who would lead us forth into the forgetfulness of Lotus-land, where lazy enjoyment lulls strenuous Duty into a fitful sleep.

Companionship plays much the same part in life as is played by our fellow-travellers when we go wayfaring on a holiday. We know then that much of the success of the adventure will depend on a right choice of our company. If its

numbers be small—only three or four—one who is a hindrance may spoil the journey; and if it be large, a few jarring natures will seriously mar the enjoyment of all. The close and continuous association brings out good and bad qualities that before were only latent, and not fully realised. So clearly is this the case that perhaps the first consideration in planning a wandering holiday is the choosing of the company. Very similar is the effect of companionships in our ordinary life. Constant association acting over long periods of time will have great effects on us in the aggregate, as the seemingly small influences of wind and rain produce on the earth's surface greater dislocations and changes than the mightiest cataclysms.

It is well that, in youth particularly, we should form a general scheme for our life, fixing some goal towards which we are going, and cherishing an ambition we mean to fulfil. Whether we pursue our original intention to its end, or are deflected aside to some better goal as life opens out before us, the definite course for the time being will have had manifest advantages. One of them will have been that it enabled us to choose our companions the more suitably. We shall probably have consorted with those who are going the same way as ourselves, in pursuit of the same ambitions, and whose association with us will be a stimulus, or an even more positive assistance, as they will bring experience to supplement our own.

Should Friends be alike or not? This introduces the important question whether companions with similar interests to ours should be chosen. Is it well to consort largely with those who are preparing for, or belong to, the same calling, profession, or life-work? The question may be argued with plausibility either way. It may be pointed out that the gathering together of men to talk "shop" incessantly is one of the most narrowing add deadening of experiences.

On the other hand, much may be said for the young who are preparing for a definite round of skilled work giving their professional zeal its head, and seeking together to master the principles of their life's work even in their spare hours. They have not worn their interest threadbare through routine; and if they do not welcome opportunities of gaining further knowledge through well-chosen companionship it is probable that their devotion to their studies is less concentrated than it should be.

Besides, in nearly every walk in life there are substantial interests to be served by men in similar callings banding themselves into companionships to some extent. Thus they find a natural sympathy with inevitable difficulties which uninitiated outsiders will be slow to give.

The common sense of a choice in companionships seems to be to accept within reasonable measure those which are helpful in our life's work, or in the furtherance of ideas which appear to us worthy of public acceptance, but to halt at the point where such companionships force us into a groove, or narrow our outlook and our power of giving a fair, summary judgment. To take refuge, in our hours off duty, as far as possible, from our business interests, to ostracise our professional associations, may be defended on the ground of a need for change, but it is much more likely to be due to a subterranean wish to appear other than we are.

The great need for companionship, whether with those whose routine interests are similar to our own, or with men whose interests are dissimilar to ours and will introduce variety into our thoughts, is that there should be stimulation, attrition, refreshment, a bracing effect in our intercourse, and that it should surround us with an atmosphere that rouses our latent energies and gives zest to our lives. There may be a few who are so highly strung that they need soporific companionships as an antidote, but they are sufficiently rare to be disregarded. It is mental and moral enlivening that most of us need.

The Easy Path to Degeneration. Companionships mass themselves, in the main, into two groups, which, judged by their effects, either cause us to be alert, keen, bright, with a development of our best powers, or slack, drifting, pleasure-loving, and inclined to follow our easiest inclinations along the lines of least resistance. We may see these tendencies at work, in their simplest forms, on any day of relaxation—on Sundays, holidays, on the evening hours of rest—when knots of young people stroll forth or "hang about" in open places, along country lanes, or beside the churchyard wall of the village. There is the group that is passing its time in company with no better impulse than sheer animal gregariousness—a liking for being together. It is thoughtless, shallow, perhaps noisy, pitiable in its inanity, ready to welcome the coarse jest that leaves a moral sore, dominated probably by the least sensitive nature present, not only unideal and unhelpful, but incipiently low if not vicious. It is repeated in the half-rowdy parades of our city streets. It reappears in older companies in the evening circle of the bar-parlour, or the so-called genial corner of the club smoke-room; and, wherever it appears, it helps no human being towards making himself more fit for doing a man's work in the world, but dissipates his mental and moral strength.

Companionship that Stimulates. But, in contrast, there are the small groups of assorted companies one sees in all the reputable resorts of men, who obviously are together for "mutual improvement," as the old phrase not inaptly runs—the men who walk afield for physical recreation, but have some further aim by the way, such as intelligent observation, or conversation, or scientific study, or appreciation of natural beauty, and at the journey's end arrive at a place that tells a story it is well to know. There are the men who deliberately use part of their leisure in the company of others like-minded with themselves that they may advance themselves in specific knowledge, or by the clash of wits secure deftness in argu-

ment, or a surer hold of their half-formed thoughts. It does not follow that these men with aims will be contentious or pragmatical; the knowledge that is gained in company is not likely to be the knowledge that "puffeth up," for undue self-esteem is likely to be deflated where other minds are busy also. Companionship that is healthily vigorous has the same effect as the best kind of school life—it puts a man on his mettle and brings him to his true level.

It should not be forgotten, however, that under many circumstances it is not in our power to choose our companions so as only to consort with those whose effect on us is likely to be helpful. That is where many of the moral maxims on the subject show a lack of breadth. It is all very well to say, "Tell me with whom thou goest, and I will tell thee what thou doest." That is true enough as far as deliberate choice of comrades will take us, but what of the enforced companionships of business life with those whose tone of mind should be a warning rather than an attraction? We need to have a thoughtful view of our association with others that will be a defence against what is deleterious yet cannot be avoided. The jostle of practical life brings together people of all ages, often of both sexes, with a wide range of moral sensitiveness, or insensitiveness; and there may be as much need for knowing how to repel the influences of unfavourable companionship which cannot be eluded as for knowing how to receive and use to advantage the influences of the men and women whose proximity ennobles life.

Companionships of Working Life. It may be said that we are enlarging the idea of companionship when we make it include the involuntary association of people together in workshops and offices, but the daily and hourly contact of people in the course of duty has all the moulding effects of a companionship, unless we thoughtfully steel ourselves against what we feel is not admirable in the methods and manners of others, and recognise for imitation whatever has the ring of truth, uprightness, and courtesy. The power to use the enforced companionship of our working circle of men and women so as to lead towards the ultimate end of Success depends on our ability to choose constantly between the good and the bad, allowing the bad to pass us by as "the idle wind which we respect not," and giving quick response to what is good. It is the pure in heart who pass unharmed through the world's conflicting companionships.

A word may be said about the ill-effects of constant companionship, or want of companionship, with inferiors, or those who through the needs of organisation and discipline pass as inferiors. From the sergeant drilling his awkward squad, the foreman carrying out his firm's rules, the schoolmaster incessantly accommodating his thoughts to the receptivity of immature minds, up to the tyrant who arrogates to himself a position high above all forms of companionship, the effects on the mind of one who deals constantly with inferiority, either real or assumed, must be unfortunate. And this may be seen in the choice of private companions. The man who chooses companions among whom he may shine is acting foolishly—possibly on their account, but certainly on his own.

Much might be written about companionships between the opposite sexes, but the most judicious will insist most strongly that doubled safeguards are necessary wherever sex complicates the question of close and constant association. The more formal all companionships between the sexes are kept, the better. Somebody has said that friendship is a wide portal through which Love easily enters unawares. That is so true that nobody can be sure, whatever circumspection may be shown on one side in keeping mixed companionships on an even keel, that the other side will be equally undisturbed.

Friendship between Young and Old. An interesting phase of companionship is its relationship to age. How far can the young and the old be companions with good effects? Of course, the young will companion with the young, inevitably and beneficially, but are those who are much older also eligible and desirable companions? The sound reply to that seems to be that it depends on whether those who are older—whatever their age may be—have retained their full sympathy with youth. If they have been young in their youth, have kept their joy in simplicity, and live again their life in the youth of others, they may be the best of additional companions to those who are still young, and wield over them an enormous influence that is wholly good. Our last suggestion is that companionship prepares for Success, inasmuch as it gives exercise in the intimate management of men. Unless a man has the power of knowing and managing men, the fields of Success open to him are severely limited. He may engage in individual scientific research; he may be the poet of his own egotism. But there is not much else open to him, except at a disadvantage. The recluse is instinctively distrusted as being odd; and the probability is that he *is* odd, because he has not the ordinary knack of accommodating himself and his interests to the moods and points of view of other men, owing to his failure to mix with them easily on a common level.

Aids in the Management of Men. That valuable working knowledge of men is learned instinctively by the average man in the pleasant and easy ways of companionship. Companions learn how to "get on" together, to understand each other's points of view, to engineer little personal adaptations, to take and give criticism, to chaff and be chaffed, and in a thousand such ways know each other, and know mankind; and so companionship is an informal school for the management of men to which the lonely and shy and proud never go. The successful man has usually come through from the ranks, and by the way has been a man among men, but he was first regimented among his companions. There, unawares, he began his life-drill in human character.

JOHN DERRY

Physical Features, Climate and Vegetation. The Yellowstone Park and the Great Plains. Occupations and Races.

NORTH AMERICA

AMERICA, or the New World, consists of two great peninsulas—North America (8,000,000 sq. miles) and South America (7,000,000 sq. miles), united by the long, narrow isthmus of Central America, which is now pierced by the construction of the Panama Canal.

At the Isthmus of Tehuantepec, which may be taken as the southern limit of North America, the distance across is 130 miles. Rather less than 4,000 miles due north is Cape Murchison, the most northerly point of the mainland. The maximum breadth of the continent is about the same. The whole of the north, except Alaska, is British, forming the self-governing colonies of Canada and Newfoundland. South of Canada is the Republic of the United States, to which belongs Alaska. South of the United States is the Republic of Mexico.

Oceans, Seas, and Gulfs. The northern shores are washed by the Arctic Ocean, the western by the Pacific, and the eastern by the Atlantic. An archipelago of islands stretches across the Arctic Ocean north towards the Pole, and east towards Greenland, which is separated by Baffin Bay from the North American mainland. In the extreme north-west, America is less than 40 miles distant from Asia across Behring Strait. The Aleutian Islands, off Alaska, continue the island fringe of Eastern Asia.

The coast of North America is much indented. On the Atlantic coast, which has marginal lowlands, are (1) Hudson Bay; (2) the Gulf of the St. Lawrence, entered north or south of the island of Newfoundland, and leading to the great lakes of Ontario, Erie, Huron, Michigan, and Superior; (3) the Gulf of Mexico. The latter, with the Caribbean Sea, which is almost cut off by the island of Cuba, is sometimes called the American Mediterranean. The islands which define its eastern limits are the West Indies. Let us look out all these on a map, and notice the names of the straits leading to them. On the Pacific coast, which is bordered by high mountains, there are fiords in the north like those of Western Scotland or Norway in the north-west. In the south is the Gulf of California, the largest gulf on the Pacific coast. It may be contrasted with the Atlantic gulfs.

Mountains. The highlands and lowlands of America are arranged in parallel belts. Along the whole length of the Pacific coast runs a continuous belt of broad high mountains, sometimes called the Cordilleras. These sink in the east to a broad, rolling plain, which extends from the Arctic Ocean to the Gulf of Mexico. Two breaks occur in its surface, which elsewhere slopes imperceptibly but uniformly from west to east. The first of these is the region west of Lake Superior. Though nowhere over 2,000 ft. high, it gives rise to the St. Lawrence, flowing due east to its gulf; the Mississippi, which flows almost due south across the central lowland to the gulf; and the Red River, which flows north to Lake Winnipeg. The second is the Ozark Mountains, which separate two of the parallel tributaries of the Mississippi which rise in the east. In the east the Central Lowland gradually rises to the Atlantic or Eastern Highlands, which, under various local names and with some breaks, can be traced from Hudson Bay almost to the Gulf. North of the St. Lawrence they are known as the Laurentian Highlands, south of the St. Lawrence as the Appalachian Highlands. These highlands fall steeply on the east to the Atlantic lowland, which widens towards the south, and is connected round the south of the Appalachians with the central lowlands, there forming what is often called the Gulf Coastal Plain.

Rivers. From this arrangement of highlands and lowlands it follows that we shall have a series of (1) short rivers flowing west to the Pacific; (2) long rivers from the eastern slopes of the western mountains, flowing east or south; (3) long rivers from the gentler west slopes of the Appalachians, flowing west; and (4) short Atlantic rivers from the steep eastern slopes of the Appalachians. The rivers from the central heights have already been named.

The longest of the Pacific rivers flow for considerable distances parallel to the mountain chains. Of these, the chief are the Yukon, flowing to Behring Strait in a long, narrow valley parallel to the coast; the Fraser and Snake-Columbia, flowing to the Pacific from the central region of the western mountains; and the Colorado, flowing to the Gulf of California.

Ease of Water Communication. The northernmost of the long rivers running east is the Mackenzie, flowing with a course nearly parallel to that of the Yukon through Athabasca, Great Slave and Great Bear lakes to the Arctic Ocean. Parallel to its upper valley are those of the Saskatchewan, which flows east to Lake Winnipeg, and thence, as the Nelson, to Hudson Bay, and those of the great rivers which flow east to the Mississippi, the Missouri, Platte, Arkansas, and Red River. The Mississippi also receives the waters of long west-flowing rivers from the eastern Appalachians, which are gathered up and carried to it by the Ohio. Of the short, rapid rivers of the Atlantic seaboard the most important are the Connecticut, Hudson, Delaware, Susquehanna, Potomac, James, and Alabama. It will thus be realised that no other continent has such admirable facilities for

water communication. North America is covered by a network of lakes and rivers, separated by inconsiderable distances, permitting easy water communication in all directions. The Great Lakes, with the St. Lawrence, open up the very heart of the continent. Lake Erie is quite near the Ohio tributary of the Mississippi. Lake Superior is even nearer to (1) the Winnipeg-Nelson system of lakes and rivers; and (2) the Mississippi. A very short canal thus gives through communication between the Gulf of St. Lawrence and the Gulf of Mexico. The source of the Mississippi is only a few miles distant from that of the Winnipeg or Northern Red River, and the three systems, St. Lawrence, Northern Red River, Nelson, and Mississippi may almost be regarded as one great system, linking together the three great Atlantic gulfs. The Mackenzie is easily reached from the Saskatchewan, thus giving access to the Arctic Ocean; but as it is frozen for many months of the year, this is of little practical importance.

The Western Mountain System. It is impossible in our limited space to study this great system in detail. In the east, the lofty Rocky Mountains rise steeply from the plains. West of these are a series of plateaux, or basins, and west of these again another series of ranges, locally known under different names. An outer coastal range is less well marked, but can be traced on the mainland and bordering islands.

The basin of the Yukon is separated from the Mackenzie by spurs of the Rockies. West and south of the valley are two parallel volcanic ranges, the northern forming the mountains of Alaska, which are connected through the Aleutian Islands with the volcanic highlands of East Asia. Mount McKinley is the highest point in North America, reaching 20,500 ft. The southern range is a labyrinth of glacier-filled valleys and snow peaks rising precipitously from the sea, the highest being St. Elias (18,000 ft.) and Logan (19,550 ft.). Over the wild southern mountain chain difficult passes, closed by snow for many months, lead to the gold-mining districts of Klondike and other centres in the Yukon basin.

British Columbia. British Columbia is a high, rugged plateau enclosed between the Rockies on the east and the Northern Cascades on the west. Beyond the Cascades a coastal range appears in the islands of Queen Charlotte and Vancouver. Where they are crossed by the Canadian Pacific Railway the Rockies are a broad system, consisting of the Summit, Selkirk, and Gold ranges. These parallel ranges are separated by long valleys in which flow the tributaries of the rivers running west. The easternmost or Summit range of the Rockies rises in sheer cliffs or escarpments above the plains, towering up in rock walls 3,000 or 5000 ft. high. The highest summit, Mount Robson (13,700 ft.), overlooks the sources of the Athabasca, flowing to the Mackenzie, the Saskatchewan, flowing to Hudson Bay, and the Fraser and Columbia, flowing to the Pacific. Many peaks rise to 12,000 ft., and vast glaciers and snowfields feed the rivers. The forests are much thinner than in the Selkirks, whose fine combination of forest, glacier, and snow peak has earned the title of the Switzerland of America. The Gold and Cascade ranges are lower, and forested almost to their summits. Across these ranges, which presented great difficulties to the railway engineers, the rivers have cut deep, gloomy cañons in which a raging river boils along at the base of perpendicularly steep walls of rock.

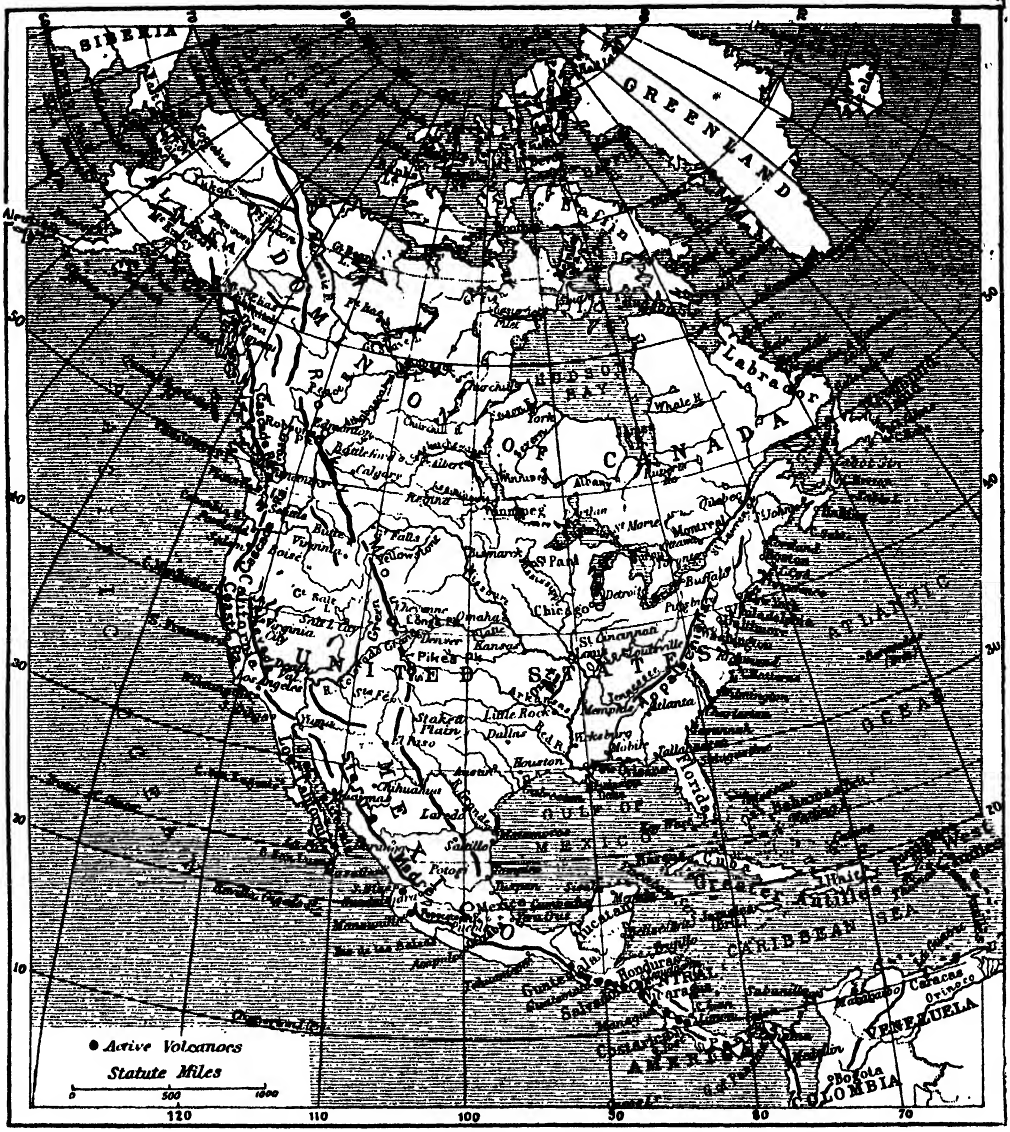
Western Mountains of the United States. The Rockies and Cascades continue south into the United States, diverging as they go. The Rockies become an intricate system of parallel ranges, which enclose high intermont valleys, locally called parks. They form the continental divide between the Atlantic and Pacific rivers. Within a relatively small area are the sources of the Missouri and Yellowstone tributaries of the Mississippi, the Snake tributary of the Columbia, the Green and Grand head streams of the Colorado, and the Rio Grande del Norte. There are spots on the Divide where the sources of two streams, one flowing to the Atlantic, the other to the Pacific, are hardly 200 yards apart.

The Yellowstone Park. The finest of these parks, set apart for national enjoyment, is the Yellowstone Park, some 75 miles square, situated on the Great Divide, about 7,000 ft. above the sea. Surrounded by an amphitheatre of mountains, and containing magnificent cascades, beautiful lakes, many geysers, hot springs, and wonderful coloured sinter terraces, it forms a natural museum unique in the world.

Far surpassing everything else in beauty is the Yellowstone Cañon, into which the river falls over the famous Yellowstone Falls. In places the walls of the cañon are 1 500 ft. high, while the width of the chasm is only half a mile. It has been cut down by the river through pale yellow or pinkish rocks, and the rocks do not weather uniformly. All along the cañon walls the harder parts project in a series of massive fretted buttresses and jagged pinnacles of the most fantastic shapes. "The whole gorge is painted in the most brilliant hues, from pale lemon yellow to deep orange, streaked with warm vermilion, crimson and purple, which, mingling with the deep green of the pines that clothe the brink of the chasm make up a picture of transcendent beauty."

Somewhat similar cañons are cut by the rivers south of the Yellowstone, where Long's Peak and Pike's Peak are both over 14,000 ft.

Idaho, Utah and Colorado. West of the Rockies lies the lava desert of Southern Idaho, cloven by the deep gorges of the Snake and Columbia Rivers. In their descent they pass over many falls, of which the Soshone Falls of the Snake are the finest. South of the Snake is the Great Basin, a district as large as France, whose waters flow to the Great Salt Lake, and other basins without an outlet. The surface is covered with short ranges of tilted block mountains, varied in colour and bare of vegetation. Between these are wide valleys covered with dry scrub, or with nitrates and other alkaline deposits. Under irrigation the



NORTH AMERICA

soil is very fertile, and the region round Salt Lake City is a veritable garden. The Wahsatch Mountains separate the Great Basin from the Colorado plateau to the east. This region consists of high arid plateaux, above which rise table-shaped mesas, or steep-sided pinnacle-shaped buttes. The Colorado and its tributaries flow in cañons similar to that of the Yellowstone but on an infinitely vaster scale. The Marble Cañon in the Painted Desert of Arizona, and the Grand Cañon of the lower Colorado, 300 miles long and in places a mile deep, are the most wonderful. This extraordinary region long baffled exploration, and is still imperfectly known. All these regions are arid, and bare of vegetation. West of the Colorado, in the lee of the Sierra Nevada, the country becomes a desert, where such names as Death Valley, a region of enormous mineral wealth, tell their own sinister tale. It is a land of burning sands, weird, distorted cactus vegetation, mirage and thirst.

The Western Rampart. The western rampart of these vast plateaux and basins is formed by the Southern Cascades, the Pacific slopes of which are densely forested. By intercepting the rainy winds they produce the arid conditions just described. Of many volcanic cones the finest are Tacoma, Hood, and Shasta (14,500 ft.), beyond which the system is continued south by the Sierra Nevada. Across the Southern Cascades there is only one natural route, the gorge of the Columbia, which cuts its way to

the sea between great basaltic cliffs in places 2,000 ft. high. The Sierra Nevada contains many peaks over 13,000 ft., whose snowy summits have suggested its name. Hidden between its parallel ranges is the Yosemite Valley, one of the beauty spots of the world. It is enclosed between rock walls of stupendous height, over which the rivers leap in magnificent cascades, the wonderful panorama of crag, forest, and cascade being mirrored in the lovely lakes of the valley floor. Between the Cascades and the Coast range is the fertile Willamette valley of Oregon, whose northern extremity forms Puget Sound. Between the Sierra Nevada and the Coast range is the rich valley of California, drained by the Sacramento.

In Mexico, the Rocky Mountains are continued by the eastern, and the Sierra Nevada by the western Sierra Madre. These form the margins of the Mexican plateau, which rises to the south, where the Sierras converge to a great volcanic chain, containing many lofty snow-clad active and extinct volcanoes. The highest are Popocatepetl and Orizaba (18,000 ft.). Beyond this the mountains sink gradually to the Isthmus of Tehuantepec, which is less than 500 ft. high.

The Great Plains. The central plains of North America extend from the Arctic to the Gulf of Mexico. In the extreme north they are a tundra region, covered by a network of lakes. This passes at the south into forests, and these in turn into grasslands. In the United States the eastern forests have been largely cleared, and rolling treeless prairies form a monotonous landscape. Some unfertile tracts occur, such as the Bad Lands of South Dakota, and the Staked Plain of Texas. Along the Gulf of Mexico the plain is of alluvial formation, and fringed with swamps and lagoons. The peninsula of Florida consists of porous limestone, through which the rivers sink. The southern part forms the Everglades, a region of forested waterways and islands. The Atlantic plain is wide and swampy in the south, but becomes narrow in the north.

The Appalachians. These stretch from Newfoundland to within 200 miles of the Gulf, averaging 450 miles in width. Newfoundland, an island of low mountains and many lakes, is cut off by the Gulf of St. Lawrence from the very similar New Brunswick and Nova Scotia.

In the United States the rugged New England Highlands are separated by the Hudson valley from the Appalachian ranges, in the narrower sense of the term. The Appalachian system, which is in reality a very ancient plateau dissected out in the course of ages into parallel ranges separated by long narrow parallel valleys, becomes higher, broader, and more rugged. To the east is the Blue Ridge, and to the west the Allegheny Plateau. The structure of the region in its present form is very complicated. The ranges have local names, which can be looked out on the map.

These broad, rugged, and densely forested highlands long prevented the westward extension of colonisation. The rivers descending from the eastern slopes, which front the Atlantic plain as steep escarpments, did indeed lead to excellent passes, but these gave access only to trough-like valleys, beyond which rose a barrier similar to that just crossed. Population for 150 years moved up and down these valleys, but could not push westward into the central plains, except in the north, where the only natural break across the entire breadth of the highlands occurred.

The Gateway of the Appalachians. This gateway of the Appalachians was the Hudson valley, a great natural opening shut in by the escarpments of the plateau on either side. Nowhere 200 ft. high, and occupied by the Hudson and Lake Champlain, it opened a natural route to the St. Lawrence, and thence by the great lakes to the west. The importance of this route is shown by the enormous prosperity of the cities founded at its terminal points—New York and Montreal.

A still more direct route to the great lakes and the west opens from the Hudson, by the valley of its tributary, the Mohawk, which leads west to the lowlands around Lake Ontario. "Seen from the railway, which follows it, the valley appears to be a trench about 500 ft. deep, with moderately steep sides, and an average width of half a mile. Seen more truly from above the bordering uplands, it is a vast gap, 1,500 to 2,000 ft. deep, and several miles wide in its higher part," cut across the entire breadth of the plateau. The Mohawk valley, which commands the great route to the west, is followed by the New York Central Railway to Buffalo. "There is not a difficult grade or an embankment or a trestle of any importance between New York and Buffalo (490 miles), and with slight exception, this holds good from Buffalo to the Rockies. Two thousand miles of splendid country are made tributary to the harbour of New York through this river gateway."

Climate. In a continent nearly 4 000 miles long we have every kind of climate, from polar to tropical, modified by elevation and distance from the sea. If we look at a map of the January isotherms, these show the same southward sweep from west to east as in Europe. Thus a great part of the continent has frost for longer or shorter periods in winter, and the centre of the continent, in the latitude of Central Italy, is as cold as Iceland. South of 35° N., there are no winter frosts. Florida and California have a January like that of Egypt, and the tropical lowlands of Mexico have a January temperature of 70° F.

In summer the isotherms are bent north. Over most of the mainland the summer temperature is not below 50° F. The isotherm of 60° F., which crosses central England, traverses North America at the southern end of Hudson Bay, and runs north as we go west. The same regions which have very severe winters have thus warm summers. The isotherm of 70° F. strikes the west coast in about latitude 30° N., and runs almost due north for 20 degrees and then crosses the continent. South of latitude 30° the summers are hot, especially in the interior, where the lands in the lee of the Rockies are cut off from cooling ocean winds.

Rain falls abundantly on the Atlantic coast from Labrador southwards, and south of Newfoundland at all seasons. The rainfall diminishes slowly but steadily as we go west, and becomes extremely scanty west of the Mississippi, where the lands in the lee of the Rockies have a very dry climate. The west coast has abundant rain, especially in the north, where it falls at all seasons. Farther south is California, with winter rains, or a Mediterranean climate. In the trade wind area the rainfall diminishes, and this explains why in the lee of the southern Rockies rainless deserts are found. If the continent were here broad, like North Africa, instead of narrow, we should have a Sahara. As it is, we have desert resembling the Kalahari.

Vegetation. The vegetation of Arctic North America is of the familiar tundra type. Much of this region, especially round the northern part of Hudson Bay, has the expressive name of the Barren Grounds. Vegetation consists of moss and lichens, or of low, berry-bearing bushes, with stunted trees in protected spots. To the south it passes gradually into poor woodland, the birch being found as far north as any of the conifers. In winter the tundra is frozen, and in spring, when the rivers are melting, it is flooded. Only in summer does it tempt north the caribou—the American reindeer. The caribou has never, like the reindeer, been domesticated, and there is consequently no summer migration of population north, as in the Old World. The Indian hunter, indeed, follows the trail of the caribou, but only for purposes of destruction. In the worst parts of the Arctic region, however, where vegetation practically ceases, we get the interesting Eskimo people, who live by slaying the creatures of the Polar Seas, bear, walrus, whale, and the like, and show great ingenuity in supplying all their wants from these animals.

A FIFTY-FEET STATUE IN MEMORY OF AN INDIAN CHIEF

Forests and Steppes. Forests succeed the tundra, both in east and west. Thousands of square miles are covered with virgin forests, containing magnificent timber. This gives rise to the important industry of lumbering. When the forest streams are frozen in winter, the lumbermen start for the woods, where they remain for several weeks, felling trees and dragging them over the firm frozen ground to the banks of the streams. When these thaw in spring, the swollen current whirls along its burden of logs to one of the great timber or lumber centres, where innumerable sawmills, turned by the river, soon transform the lumber into timber, wood pulp, and its products. Beyond the forests, in the dry centre of the continent, we find the dry steppes or grass lands, generally called the prairies. Where the rainfall is sufficient for cereals, wheat is grown in the north and maize further south. The dry western prairies are used for cattle-breeding. Many thousands of acres go to form a cattle ranche, on which thousands of head of stock run in a semi-wild condition.

The belt of desert in North America is relatively small. Neither savannas nor tropical forests are found, except in parts of Mexico and Florida.

Occupations. Hunting is the only means of livelihood for the Eskimo of the Arctic Ocean, Hudson Bay, and Greenland. The trapping of fur animals is important on the tundra and forest margins. Large herds of buffalo once roamed the prairies, and were hunted by numerous Indian tribes, but the white man exterminated them with more than savage recklessness.

In the forests lumbering is important, and supports such industries as saw-milling, pulping, and paper-making in the towns on the forest margin. In the eastern prairies wheat is grown on a vast scale. Flour-milling is important in towns adjacent to the wheat-belt. All the western mountains are rich in minerals, and mining is important in many parts. The sea fisheries of both the west and east coast are very valuable, especially in Canada and Newfoundland. The northern rivers of the Pacific slope teem with salmon, which are canned in immense quantities.

The industries of the towns are very varied. Manufactures are carried on where water is plentiful, especially in the United States at the base of the Appalachian highlands and on the coalfields.

Races. The original Indian inhabitants are now comparatively few in number, and confined to the tundra, the forests, or their own reservations. The modern American is of European descent. Except in the lower St. Lawrence basin. British blood predominates in Canada, as well as in the United States, though all European nations are well represented. Spanish blood is pre-eminent in Mexico, where Spanish is spoken, and the religion is Roman Catholic. The rest of the continent is English-speaking, and mainly Protestant. Negroes of African descent are numerous in the southern United States, and Chinese have settled on the Pacific coast.

A. J. AND F. D. HERBERTSON

How to Draw the Skeleton Cube and Vases. Memory Drawing. Plane Figure Areas and Plane Curves.

OBJECT DRAWING AND GEOMETRY

Skeleton Cube. To many students the skeleton cube seems to be a very difficult object to draw correctly, and perhaps it is so, especially when it is in positions similar to that shown in **310**; but most, if not all, the difficulties will be overcome if sufficient care is given to the preliminary but thorough analysis and observation of the model before drawing a single line. For example, it will be seen that the edges may be divided into *three* sets—viz., first, a *vertical* set; secondly, all those vanishing to the *right*, and thirdly, those receding to the *left*, as in **308**. In **309** there are vertical and horizontal sets, with a third set receding straight away in front of the spectator. In **310** will be seen a set vanishing upwards to the right, another upwards to the left, and a third set downwards to the right. The above examinations of the object ought to enable the student to make no errors in the direction and apparent convergence of receding parallel edges. Begin by drawing the appearance of the object as if it were a solid cube, as shown in small sketches in **309**, being very careful to keep the true relative apparent proportions between the different faces.

Next, having noticed the proportion of the apparent thickness of the bars, sketch the vertical lines *AB*, *CD*, *EF*, and *GH*, which represent the bars of the vertical visible faces, and then the lines *AC*, *BD*, *EG*, and *FH*, for the receding edges of the same faces. The top surface is then easily obtained by producing the vertical edges *BA*, *DC*, *FE*, and *HG*, to the top front receding edges *JK* and *JL*, and from the points *M*, *N*, *O*, and *P* draw lines converging right and left with *JK* and *JL* in **308**. The next step is an important one, and that is drawing accurately the position of the edges *QR*, *HS*, and *DT*, which should all intersect at *one* point, *V*. If they do not do so, then the student may be certain that he has made a mistake previously in the convergence of the other edges or the proportion of the faces. The rest of the drawing should be found very simple, especially if the student will notice the connection between the various edges as shown by dotted lines.

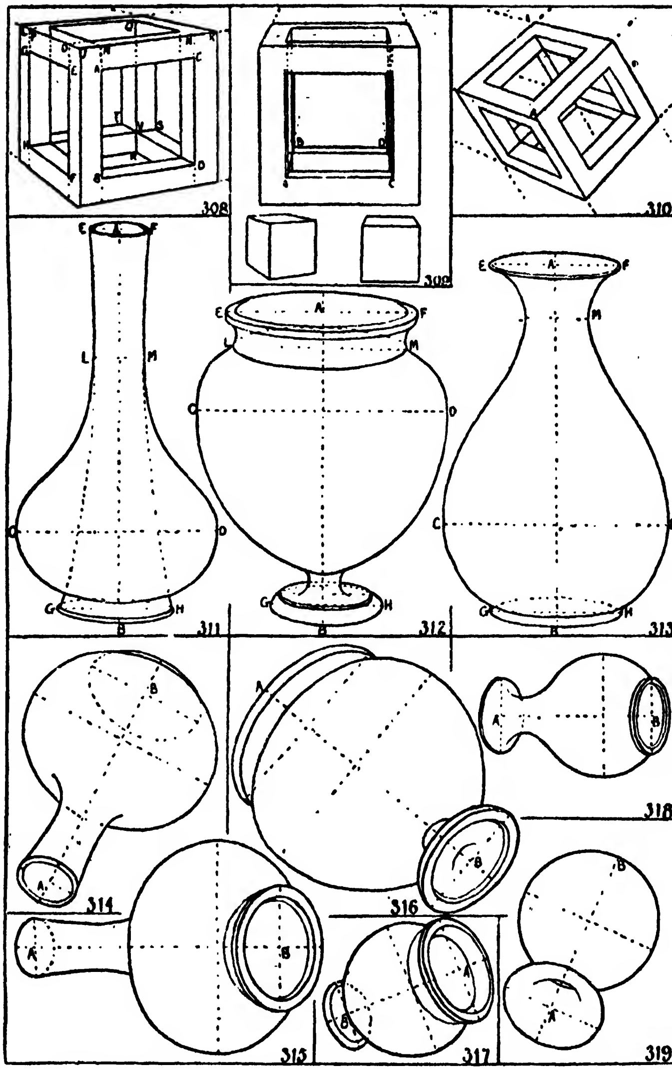
In **309** will be seen an instance of very much foreshortening of the thickness of the inner surfaces of the bars; this will need special care. We must not forget that the edges *AB* and *CD* should appear to converge to the same point as the edges which recede at the top. The observer is supposed to be opposite the front vertical face of the cube, which is below the eye level. When the cube is tilted, as shown in **310**, we have a somewhat more difficult view to draw, but method and keen observation will overcome the difficulties. Start by fixing the position of the nearest corner *A*, then the direction of the three lines radiating from it. Each of these lines belongs to a different set, and all others depend upon them for correctness in every respect; therefore great care should be given to deciding their apparent direction and length. The rest of the drawing is then as easy as in **308**, for the student has only to obey the rule of apparent convergence of receding parallel edges, and observe their relative proportions.

Vases. The vases chosen for models in this course are those to be found in all art schools, but other vases will do just as well for examples to study. **Fig. 311** is a view of the vase known as the white bottle, **312** as the terra-cotta vase, and **313** as the red glazed one—all standing, of course, in a vertical position.

When the vases are symmetrical in form and standing in a vertical position, as in **311–313**, begin by sketching the upright axis *AB* of the vase; then determine the greatest width, both as regards position and proportion, and draw the line *CD* to represent them, noticing carefully that it *appears at right angles to the axis AB of the object*. Next draw the major axes of the various ellipses, such as *EF*, *GH*, etc., again observing that the axes are always perpendicular to *AB*, and then fix the position of the narrowest part of the neck, such as *LM*. Now proceed to sketch the main contour lines and the curves for the ellipses, all the time endeavouring to realise the beautiful form of the vase, which sometimes requires the line to curve slowly and at others more quickly. Great attention should be given to the rims, bases, and mouldings, if any, observing the apparently greater width of the rims at the ends of the major axis, as in **312**. Notice the apparent connection (shown by dotted curved lines in **311**) between the neck and the base; the *elliptical* form of the body in **311**; the *oval* form of that in **312**, and the *circular* or *globular* shape in **313**. Do not make the very common error of drawing a horizontal straight line for the bases, for as these are really circular in shape, and below the eye level, they must appear as part of ellipses. The base can appear as a straight line only when it is exactly level with the eye, and, if lying in an oblique position, when the *plane of the base* would pass directly through the observer's eyes.

Oblique Positions of Vases. These positions often cause great trouble to beginners, but very little should be experienced if the student will first of all draw the correct direction and length of the axis *AB* of the vase; and observe that the greatest width, the narrowest part of the neck, and the major axes of the

ellipses are *always at right angles to the axis AB of the object.* The student should place the vases in such positions as shown in **314-319**, and verify the above laws. In these oblique positions of the vases, peculiar appearances of the rims, interiors, and bases will be noticed, and much careful observation will be necessary for the mind to perceive them. All the representations in **314-319** are those of the vases lying down *on a horizontal plane,* sometimes with the mouth, at others the base, towards the spectator. Figs. **315** and **318** are of special interest, for they are splendid views for finding out whether the student will draw what he *sees,* instead of what he *knows.* As stated before, the vases are lying *on a horizontal plane,* with the axis of the objects really slanting downwards away from the observer, yet this axis in each view shown in **315** and **318** *appears horizontal;* but it must be remembered that this is only so when the vase is turned away at a *particular angle,* for it is quite possible to have the axis of the object—when its base is towards the observer—apparently slanting downwards or upwards; and the student should make experiments with the vases in various positions.



308-319. LESSONS ON THE SKELETON CUBE AND VASES

General Observations. The student has now had all the main principles of object-drawing explained to him; and the more practice he gets, the more he will find how often these principles are employed, and what sure guides they are to the correct drawing of any object he may wish to represent. But he should not stop here, for there is still much to be done, and of much more interest, when light and shade and colour are involved. Yet tone and colour will not hide bad drawing—rather, they will emphasise it; therefore, it is most necessary to *learn to draw correctly,* which can only be accomplished by continual and regular practice.

Memory Drawing. This is, without doubt, one of the most important branches of drawing, and should be cultivated as early as possible. It is a powerful stimulus to the imagination, besides being a means of cultivating confidence and self-reliance in the student. To make true progress in this subject, as in all others, method is required. The student should begin by placing at a convenient distance and level some simple rectangular object, such as a box, book, stool, table, or either of the rectilineal geometrical models used in object-drawing, and make a most careful observation concerning their apparent general proportion and direction of receding edges, and not forget the important rule: "Draw what you see, and not what you know." It is most essential that these main facts should be observed correctly, and then the details will give little trouble. These observations may be finished in three or four minutes. Having marked the position of the object, so that it may be again placed in exactly the same position, remove the object from sight, and then make a fair-sized drawing of it from memory. Now replace the object in its former position and compare the drawing with it. The same procedure may be adopted with regard to curved and more difficult objects, such as a cup and saucer or a silk hat.

The student should practise regularly, and eventually he will be able to draw with ease, from memory, flowers, plants, and even animals.

Principles Concerning Areas of Plane Figures. In order to understand more thoroughly the following principles, it would be well for beginners to go through Euclid's demonstrations of them.

1. *Parallelograms* upon the same base, or upon equal bases, and between the same parallels, are equal [Euc. I., 35 and 36]. Thus $ABCD = ABDE$ [**320**], or $ABCD = ABFE$ [**321**], or $ABCD = EFHG$ [**322**].

2. *Triangles* upon the same base, or upon equal bases, and between the same parallels, are equal [Euc. I., 37 and 38]. Thus, $ABC = DBC$ [**323**], or $ABC = DEF$ [**324**].

3. If a parallelogram and a triangle be upon the same base, and between the same parallels, the parallelogram shall be double the triangle [Euc. I., 41]. Thus, $ABCD$ = twice ABC [**325**], or $ABCD$ = twice EBC [**326**].

4. The square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides [Euc. I., 47]. This fact was discovered by Pythagoras, 580 B.C. Thus, the square $ABCD$ = square $EGFB$ + square $AEHJ$ [**327**].

NOTE. This is true of other figures constructed upon the sides of a right-angled triangle as long as they are similar. Thus, the hexagon $ABKLMN$ = hexagon $BEOPQR$ + hexagon $AESTUV$ [**327**].

5. *Parallelograms* and *triangles* upon the same base have their areas in the same ratio as their altitude. Thus, $ABEF$ = twice $ABCD$ [**328**], or ABD = four times ABC [**329**].

6. Parallelograms and triangles *of the same altitude* are to one another as their bases [Euc. IV., 1]. Thus, $ABCD = \frac{2}{3}\ BEF$ [**330**], or ABC = three times ABE [**331**]

7. The area of a rectangle is equal to that of a triangle upon the same base, but having twice the altitude. Thus, $ABCD = ABE$ [**332**].

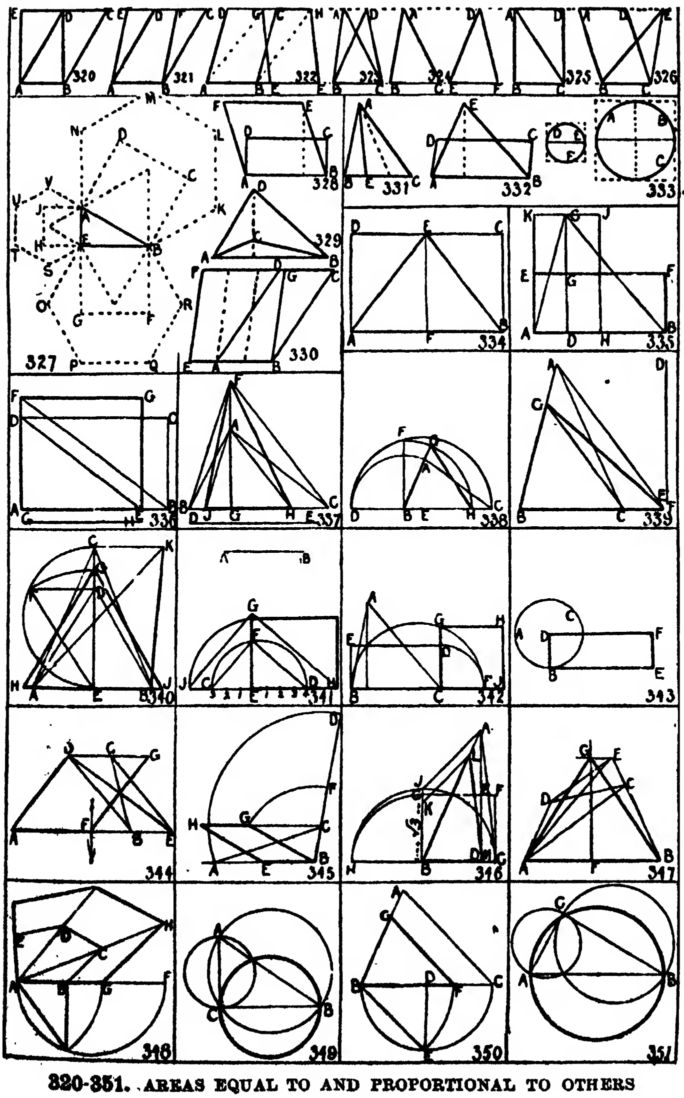
8. The areas of circles are proportional to the squares on their diameters. Thus, the circle ABC = four times DEF [**333**].

334. To Draw an Isosceles Triangle whose Area shall be Half that of the Given Rectangle $ABCD$. Bisect AB by the perpendicular FE, cutting CD in E. Join AE and BE, and AEB is the required triangle.

335. To Construct a Rectangle Equal in Area to the Given Triangle ABC. At A and B erect AE and BF perpendiculars to AB. From C draw CD perpendicular to AB (or AB produced), and cutting it in D. Bisect CD in G, and draw EGF parallel to AB and cutting AE in E and BF in F. Then $ABFE$ is the rectangle required.

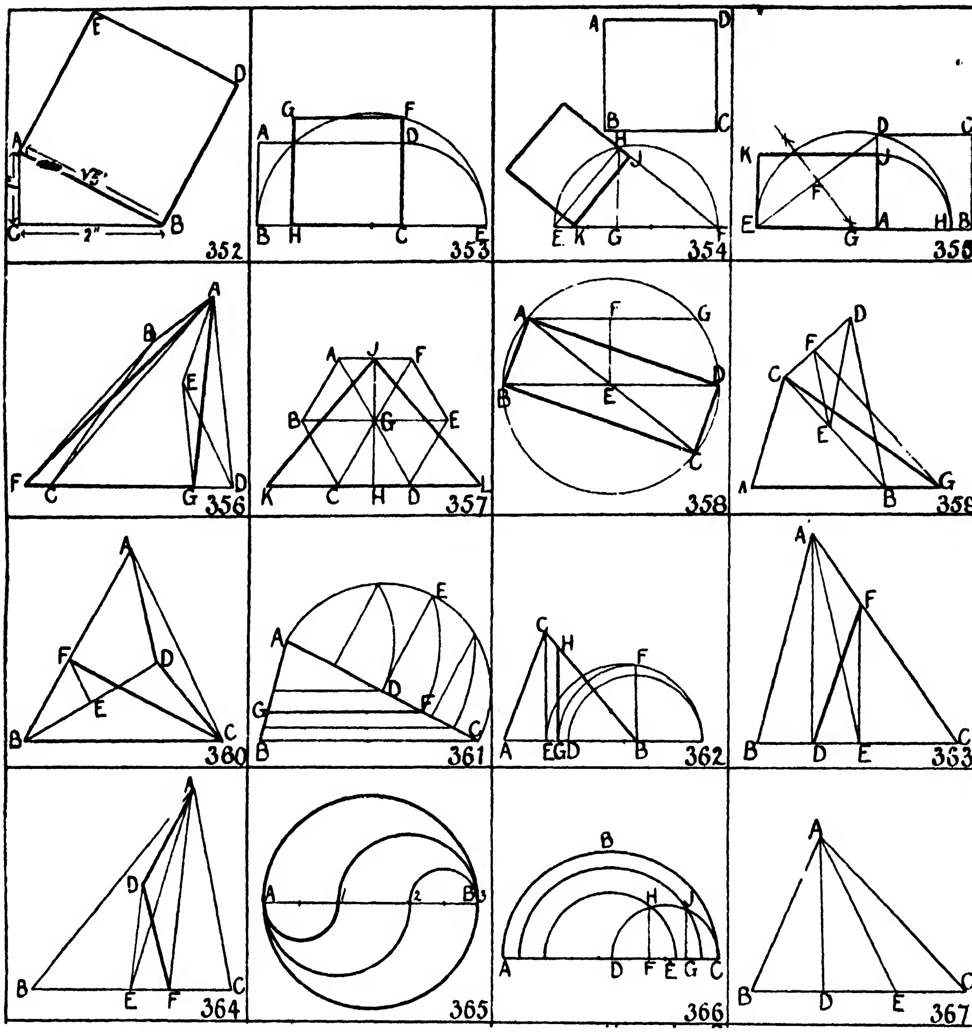
NOTE. The rectangle $AHJK$ shows that the area of a triangle may also be expressed as the altitude multiplied by half the base.

336. To Construct a Rectangle Equal in Area to the Given Rectangle $ABCD$, and One Side to be Equal to GH. Then the other side of the required rectangle must be a fourth proportional to AB, GH, and AD. Set off along AB from A, the given side AE equal to GH. Join E and D, and through B draw BF parallel to ED, cutting AD produced in F. Through F draw FG parallel to AB, and through E draw EG parallel to AF. Then $AEGF$ is the required rectangle.



320-351. AREAS EQUAL TO AND PROPORTIONAL TO OTHERS

337. To Construct a Triangle of a Given Height DE,



352-367. CONSTRUCTION AND DIVISION OF PROPORTIONAL AREAS

AND EQUAL IN AREA TO THE GIVEN TRIANGLE *ABC*. Through *A* draw *FG* perpendicular to *BC* and equal to the given height *DE*. Join *FB* and *FC*, and through *A* draw *AJ* and *AH* parallel to *FB* and *FC* respectively, cutting *BC* in *J* and *H*. Join *FJ* and *FH*, then *FJH* is the triangle required.

338. TO CONSTRUCT AN ISOSCELES TRIANGLE EQUAL IN AREA TO THE GIVEN TRIANGLE *ABC*, AND WITH ONE OF ITS ANGLES EQUAL TO ONE OF THOSE IN THE TRIANGLE *ABC*. Find the mean proportional *BF* to *BA* and *BC*. With centre *B* and radius *BF* describe an arc cutting *BA* produced in *G* and *BC* in *H*. Join *G* and *H*, then *GBH* is the required triangle.

339. ON A BASE EQUAL TO *DE* TO DESCRIBE A TRIANGLE EQUAL IN AREA TO THE GIVEN TRIANGLE *ABC*. On *BC*, or *BC* produced, set off *BF* equal to *DE*. Draw *AF*, and from *C* draw *CG* parallel to *AF*. Join *G* and *F*. Then *GBF* is the triangle required.

340. TO CONSTRUCT AN EQUILATERAL TRIANGLE EQUAL IN AREA TO ANY GIVEN TRIANGLE *ABK*. Through *K* draw *KC* parallel to the base *AB*. Bisect *AB* by the perpendicular *EC* cutting *KC* in *C*. Join *CA* and *CB*, thus obtaining an isosceles triangle, *CAB*, equal in area to *ABK*. Upon *AB* describe the equilateral triangle *ABD*. Now find the mean proportional *EF* to the altitudes *ED* and *EC* of the two triangles *ABD* and *ABC*. With *E* as centre, and radius *EF*, describe an arc cutting *EC* in *G*. Through *G* draw *GH* and *GJ* parallel to *DA* and *DB* respectively, and cutting *AB* produced in *H* and *J*. Then *GHJ* is the required triangle.

341. TO CONSTRUCT A RECTANGLE WITH SIDES IN THE RATIO OF 3 TO 4, AND AN AREA EQUAL TO THE SQUARE ON *AB*. Draw any straight line *CD*, divided in the ratio 3 to 4 at *E*. Find a mean proportional *EF* to *CE* and *ED*. Produce *EF* to *G*, making *EG* equal to *AB*. Draw *GJ* and *GH*

parallel to FC and FD respectively, cutting CD produced in J and H. Construct the required rectangle with sides equal to EJ and EH, as shown.

342. To Construct a Square Equal in Area to a Given Triangle ABC. On the base BC make a rectangle $BCDE$ equal to the triangle ABC. Find a mean proportional CG to BC and CD. Then CG is one side of the required square.

343. To Construct a Rectangle Equal in Area to a Given Circle ABC (approximate). Draw any radius DB for a short side of the rectangle. Divide DB into 7 equal parts. Draw BE perpendicular to DB, and equal to $3\frac{1}{7}$ times DB. Complete the rectangle $DBEF$ as shown.

344. To Construct a Parallelogram Equal in Area to a Given Trapezoid $ABCD$. Join two opposite corners, D and B, and through C draw CE parallel to DB, cutting AB produced in E. Bisect AE in F. From F draw FG parallel to AD, cutting DC produced in G. Then $AFGD$ is the required parallelogram.

345. To Construct a Parallelogram Equal in Area and Perimeter to the Given Triangle ABC. Produce either side, say BC, to D, making CD equal to CA. Bisect AB in E, and BD in F. Through C draw CH parallel to BA. With B as centre, and radius BF, describe an arc cutting CH in G. Join BG, and through E draw EH parallel to BG. Then $EBGH$ is the required parallelogram.

346. To Draw a Triangle of a Given Shape ABC and Area Equal to, say, 3 sq. in. From A draw a perpendicular AD to BC, and bisect it in E. Make the rectangle $BCFG$ equal in area to the triangle ABC. With B as centre, and radius BG, describe the arc GH, cutting CB produced in H. Find BJ the mean proportional to CB and BH. Along BJ, or BJ produced, set off BK equal to $\sqrt{3}$ (the mean proportion of 3 and 1). Join JA, and from K draw KL parallel to JA, and cutting AB in L. Through L draw LM parallel to AC. Then LBM is the required triangle.

347. To Construct an Isosceles Triangle Equal in Area to a Given Trapezium $ABCD$, with One Side AB Common to Both Figures. Join AC, and from D draw DE parallel to AC, and cutting BC produced in E. Join AE. Then the triangle ABE is equal to the trapezium. Bisect AB by the perpendicular FG, and through E draw EG parallel to AB, and cutting FG in G. Draw GA and GB. Then ABG is the required triangle.

348. To Construct any Figure Similar to a Given One $ABCDE$, and Having its Area in any Proportion to it, say, 3 : 1. Let AB be the one equal part, and make AF equal to 3 times AB. Find a mean proportional AG to AB and AF. Then AG is the base of the required figure to be completed as shown.

349. To Describe a Circle Equal in Area to the Difference of Two Others. Let AB be the diameter of one given circle, and upon AB describe the circle. With A as centre, and AC (the diameter of the other given circle) as radius, cut the first circle in C. Join AC and upon it describe the second given circle. Join CB and upon CB describe the required circle.

350. To Construct a Figure Similar to a Given One ABC, but Half its Area. On BC describe a semicircle, and bisect it by DE. Draw BE and make BF equal to it. Through F draw FG parallel to CA. GBF is the required figure.

351. To Describe a Circle Equal in Area to the Sum of Two Others. Draw AC and CB (the diameters of the given circles) perpendicular to each other, and describe the given circles upon AC and CB. Join AB, which is the diameter of the required circle.

352. To Make a Square whose Area shall be Equal to 5 sq. in. Draw a line AC, 1 in. long, and perpendicular to it CB, 2 in. long. Join AB, which is equal to $\sqrt{5}$. Upon AB describe the required square $ABDE$.

353. To Make a Square Equal in Area to a Given Rectangle $ABCD$. Find a mean proportional CF to BC and CD. Upon CF describe the required square $CFGH$.

354. To Construct a Square whose Area shall be a Fractional Part (say $\frac{2}{3}$) of that of a Given Square $ABCD$. Upon any straight line EF set off EG and GF, two and three convenient equal divisions. Upon EF describe a semicircle, and find GH the mean proportional to EG and GF. Join HE and HF. From F along FH, set off FJ equal to the length of the side of the given square. Through J draw JK parallel to HE. Upon JK describe the required square, as shown.

355. To Construct a Rectangle Equal in Area to a Given Square $ABCD$, and One Side of the Rectangle to be a Certain Length, as EA. Place the given side, EA, of the rectangle perpendicular to a side of the square, as EA and AD. Join DE and bisect it by the perpendicular through F, cutting EA in G. With G as centre, and GE or GD as radius, describe a semicircle, cutting EA produced in H. Then AH is the other side of the required rectangle, as shown.

356. To Reduce any Irregular Figure, as $ABCDE$, to a Triangle of Equal Area. Join AC, and through B draw BF parallel to AC and meeting DC produced in F. Join AF, and the triangle AFC equals the triangle ABC in area. Join AD, and through E draw EG parallel to AD, cutting CD in G. Join AG, and the triangle AEG equals (in area) the triangle EGD. Then AFG is the required triangle.

357. To Construct a Triangle Equal in Area to a Regular Polygon, as $ABCDEF$. Divide the polygon into equal triangles by lines drawn through the centre G, then GCD is $\frac{1}{6}$ of the polygon. Make HJ twice the height of HG, and KL three times CD. Join JK and JL. Then JKL is one triangle equal in area to the polygon. Other triangles may be drawn equal in area.

358. In a Given Circle to Inscribe a Rectangle of a Given Area. Draw any diameter BD, and from the centre E draw EF perpendicular to BD, making EF such a length that $EF \times ED$ is one half the given area. Through F draw AG parallel to BD and cutting the circle in A and G. Join either of these points,

say A, to B and D. Through E draw AC, cutting the circle in C. Join BC and CD. Then $ABCD$ is the rectangle required.

359. TO CONSTRUCT A TRIANGLE EQUAL IN AREA TO THE SUM OF TWO GIVEN TRIANGLES ABC and CED. Place them so that a side CB of one is in the same line as a side CE of the other, and a corner C adjacent with a corner C of the other. Join BD, and through E draw EF parallel to BD and cutting CD in F. Through F draw FG parallel to CB and cutting AB produced in G. Join CG, and AGC is the triangle.

Proportional Division of Areas

360. TO BISECT ANY IRREGULAR QUADRILATERAL FIGURE $ABCD$ BY A STRAIGHT LINE DRAWN THROUGH ONE OF ITS CORNERS C. Draw the diagonals AC and BD. Bisect BD (the diagonal opposite the given point C) in E. Through E draw EF parallel to AC, cutting AB in F. Join FC, which bisects the figure.

361. TO BISECT A GIVEN TRIANGLE ABC BY A LINE PARALLEL TO ONE OF ITS SIDES. On either side, say AC, construct a semicircle, and at the centre D erect a perpendicular DE to AC. With A as centre and AE as radius describe an arc cutting AC in F. Through F draw FG parallel to BC. FG bisects the triangle ABC. The other construction shows how to divide the triangle into four equal parts.

362. TO BISECT A GIVEN TRIANGLE ABC BY A LINE PERPENDICULAR TO ONE OF ITS SIDES, SAY AB. Bisect AB in D, and from C draw a perpendicular CE to AB, cutting it in E. Find BF, the mean proportional to BD and BE. Set off BG equal to BF. From G draw a perpendicular GH to AB. GH bisects the triangle.

363. TO BISECT A TRIANGLE ABC BY A LINE DRAWN THROUGH A GIVEN POINT D IN ONE OF ITS SIDES. Bisect BC in E, and join AD. Through E draw EF parallel to AD, cutting AC in F. Join DF, which bisects the triangle.

364. TO DIVIDE A GIVEN TRIANGLE ABC INTO TWO EQUAL PARTS BY LINES DRAWN THROUGH ANY GIVEN POINT D WITHIN IT. From the corner of the triangle nearest the point D draw a line AE bisecting the opposite side BC in E. Join DE, and through A draw AF parallel to DE, and cutting BC in F. Then the lines DA and DF bisect the triangle.

365. TO DIVIDE A CIRCLE INTO ANY NUMBER (SAY THREE) OF PARTS EQUAL IN AREA AND PERIMETER. Draw a diameter AB, and divide it into the same number of equal parts as the circle is to be (three in this case). Describe semicircles on opposite sides as shown.

366. TO DIVIDE A SEMICIRCLE INTO ANY NUMBER (SAY THREE) OF EQUAL PARTS BY CONCENTRIC SEMICIRCLES. Bisect the radius DC in E. With E as centre, and EC or ED as radius, describe a smaller semicircle. Divide DC into the same number of equal parts (in this case three) into which the given semicircle is to be divided, and erect the perpendiculars to DC from F and G, cutting the smaller semicircle in H and J. With D as centre, and DH and DJ as radii, describe the concentric semicircles which trisect the large given semicircle.

367. TO DIVIDE A GIVEN TRIANGLE ABC INTO ANY NUMBER OF EQUAL PARTS (SAY THREE). First, BY LINES DRAWN THROUGH ONE OF ITS CORNERS A. Divide BC (opposite A) into three equal parts in D and E. Join AD and AE, which trisect the given triangle.

368. THE SAME. BUT, SECONDLY, BY LINES DRAWN THROUGH A FIXED POINT D IN ONE OF THE SIDES. Divide AB (the side containing the given point D) into three equal parts in E and F. Join D to the opposite corner C, and draw EG and FH parallel to DC, cutting AC in G and BC in H. Join DH and DG, which trisect the given triangle.

369. THE SAME. BUT, THIRDLY, BY LINES PASSING THROUGH A FIXED POINT D WITHIN THE GIVEN TRIANGLE ABC. Divide one of the sides, say BC, into three equal parts in E and F. Join AE and AF. Also join D to A and E, and through A draw AH parallel to DE, cutting BC in H. Join DH, then $ABHD$ is one of the required three equal parts. Next, join D to F, and through A draw AG parallel to DF, cutting BC produced in G. Join DC, and through G draw GJ parallel to CD, cutting AC in J. Join DJ, then ADJ and $DHCJ$ are the other two required equal parts.

370. TO DIVIDE A PARALLELOGRAM $ABCD$ INTO ANY NUMBER OF EQUAL PARTS (SAY THREE) BY LINES PASSING THROUGH A GIVEN POINT E IN ONE OF THE SIDES. Divide BC into the required number (three) of equal parts in F and G. Draw FH and GJ parallel to AB or CD, and cutting AD in H and J. Bisect FH in K, and GJ in L. Through K and L draw EM and EN, cutting AD in M and N respectively. Then EM and EN trisect the given parallelogram.

371. TO DIVIDE A GIVEN PARALLELOGRAM $ABCD$ INTO ANY NUMBER (SAY FIVE) OF EQUAL PARTS BY LINES DRAWN THROUGH ONE OF ITS CORNERS A. Divide each of two adjacent sides DC and CB into the same number (in this case five) of equal parts, into which the parallelogram is to be divided. Draw lines from A to 2 and 4 in DC, and to 2 and 4 in BC, and these lines divide the parallelogram into five equal parts. The same method may be used for dividing a square or oblong into equal or proportional parts.

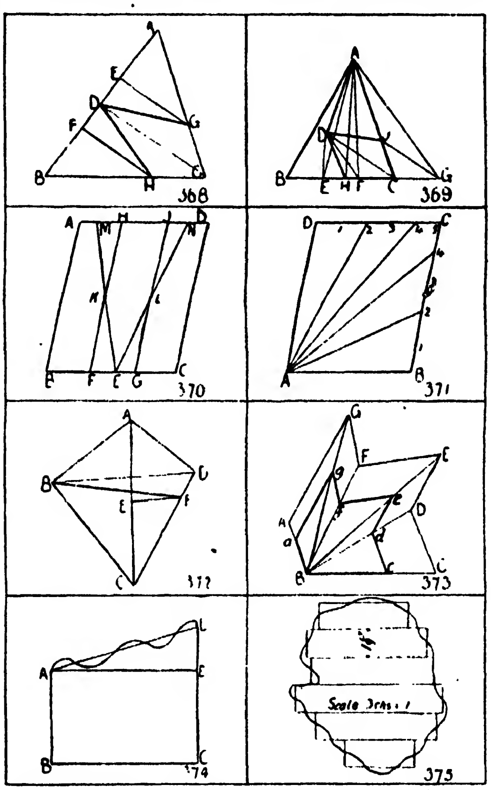
372. TO BISECT A GIVEN TRAPEZIUM $ABCD$ BY A LINE DRAWN FROM ONE OF ITS CORNERS B. Draw the diagonals AC and BD. Bisect AC in E, and draw EF parallel to BD, cutting CD in F. Join BF, which is the line of bisection.

Reducing and Enlarging Figures

373. TO REDUCE A GIVEN IRREGULAR FIGURE $ABCDEFG$ TO A SIMILAR ONE WHOSE SIDES SHALL BE, SAY, THREE-FIFTHS OF THOSE OF THE GIVEN FIGURE. Divide the figure into triangles by the lines BD, BE, BF, and BG, drawn from B, one of the corners. From B, along BC, set off Bc, equal to three-fifths of BC, and through c draw cd parallel to CD, cutting BD in d. Complete the figure $aBcdefg$ by a series of parallels, as shown. Complicated figures may be reduced or enlarged by the use of squares, as explained in problem **116**.

374. To Find the Area of a Figure Bounded by Three Rectangular Lines and an Irregular Curved Line, as *ABCD*. Draw a straight line *AD* through the curve, so that *AD* becomes a give-and-take line—that is, so that it cuts off as much as it adds to the figure. Then draw *AE* parallel to *BC*, cutting *CD* in *E*. The area of *ABCD* is then equal to $(AB \times BC) + (AE \times \frac{DE}{2})$.

375. To Find the Approximate Area in Acres of a Field Represented by an Irregular Curved Line, as Shown. The area could be found by the method used in the preceding problem [**374**], but surveyors often use a method of setting out a series of parallel lines (on the plan of the field) a certain distance apart, according to scale. If the scale is 3 chains to 1 in., then the distance apart of the parallels $= \frac{10}{3^2} = \frac{10}{9} = 1\frac{1}{9}$ in. (The numerator 10 is taken because there are 10 square chains in an acre.) The parallels are thus drawn $1\frac{1}{9}$ in. apart. Perpendiculars are drawn at the ends in a give-and-take way. Then every *inch in length* If the strips, which are $1\frac{1}{9}$ in. wide, represents an acre.



368-375. DIVISION AND REDUCTION OF PROPORTIONAL AREAS

Plane Curves. There are curves which cannot be drawn by the ordinary compasses; therefore a number of points are found first, and the curve is then drawn freehand or with the aid of French curves, through these points.

When a right cone is intersected by planes in various directions, the intersections give what are known as the *conic sections*. They are, as in **376**, the *circle*, when the plane is perpendicular to the axis, or parallel to the base of the cone; the *ellipse*, when the plane is inclined, and passes through opposite sides of the cone; the *parabola*, when the plane is parallel to the generator *CD* [**376**] of the cone; the *hyperbola*, when the plane is so inclined that its angle with the axis *AB* is *less* than that made with the generator [**376**].

The cone is supposed to be generated thus: *AB* is a fixed *axis*, and *CD*, the *generator*, is a straight line intersecting *AB* at *V*, the *vertex*. *CD* is then revolved around *AB*, at a constant angle with *AB*, thus generating the surface of a right circular cone [376].

The Ellipse. An ellipse has two *foci*, *F* and *f* in **377**, and two *directrices*, *EG* and *HJ*. The line *AB* is called the *transverse* or *major axis*, and *CD* the *conjugate* or *minor axis*; these axes are perpendicular to each other. A line drawn through the centre *O* and terminated both ends by the curve of the ellipse is a *diameter*, as *KL*.

Any straight line perpendicular to the major axis is called an *ordinate*, as *mn*, and *mp* is a *double ordinate*. A *tangent* is a line, as *MN*, which touches the curve in one point, and a *normal* is a perpendicular, as *PQ*, to a tangent at the point of contact. It should be remembered that if any point in the curve of the ellipse be joined to the foci by two straight lines, such as *FC* and *Cf*, or *FL* and *Lf*, these two lines are together equal to the major axis *AB*.

377. To Describe an Ellipse, the Major (*AB*) and Minor (*CD*) Axes being Given. First Method, by Means of a Piece of Thread. Place the two axes so that they are perpendicular to and bisect each other at *O*. With radius *AO* (half the major axis), and centre *C*, describe an arc cutting *AB* in *F* and *f*, which are the foci. Place three pins, one at each of the points *F*, *C*, and *f*, and tie a piece of thread round *F*, let it pass round *C*, and tie again round *f*. Remove the pin at *C*, and replace it with a pencil. Move the point of the pencil round, keeping the thread taut all the time, and the curve thus described is the ellipse.

378. The Same. Second Method, by Intersecting Arcs. Place the axes and find the foci as before. In *FO* take any number of points as 1, 2, 3. (It is better to make the distances 1 2, 2 3, 3 *O*, unequal, with the smallest division next to *F*, as shown.) With radius *A*1 and centres *F* and *f*, describe four arcs at *e*. With *B*1 as radius and the same centres, intersect these arcs at *e*. With radius *A*2 and the same centres, describe four arcs at *g*, and with radius *B*2 and the same centres, intersect these arcs at *g*. With radius *A*3 and centres *F* and *f*, describe four arcs at *h*, and with radius *B*3 intersect them at *h*. Draw the ellipse through the points *e*, *g*, *h*, *A*, *D*, *B*, and *C*.

379. The Same. Third Method, by Intersecting Lines. Place the axes as before, and through their extremities draw parallels to the

axes, making a rectangle *EFGH*. Divide *AE* into any number of equal parts (say four), and join each of these points with *C*. Divide *AO* into the same number of equal parts, and from *D* draw lines through 1, 2, 3, and 4, to intersect those from *C*. Through the respective points of intersection draw the curve *AC*. Proceed in the same manner, as shown, with the other three quarters of the ellipse.

380. THE SAME. FOURTH METHOD, BY MEANS OF A STRAIGHT EDGE, OR PAPER TRAMMEL. Place the axes as before. Take a piece of paper, or long flat ruler if the ellipse be large, and make *EF* equal to *AO*, and *EG* equal to *CO*. Place it—the trammel—so that *F* is on the minor axis, and *G* on the major axis. *E* is then a point on the curve. Any number of points may thus be found, being careful always to keep *F* on the minor and *G* on the major axis. Draw the ellipse through the points thus obtained.

381. TO DESCRIBE AN ELLIPSE PASSING THROUGH ANY THREE POINTS *A*, *B*, *C*, NOT IN THE SAME STRAIGHT LINE. Join *A* and *B* and bisect in *O*. Join *CO*, and produce, making *OD* equal to *CO*. Draw parallels to *AB* through *C* and *D*, and to *CD* through *A* and *B*, thus forming a parallelogram. Proceed as in problem **379**.

382. TO FIND THE CENTRE, AXES, AND FOCI OF A GIVEN ELLIPSE. Draw any two parallel chords *EF* and *GH*, and bisect them in *J* and *K*. A line through *J* and *K*, and terminated by the curve, is a diameter. Bisect it in *O*. With *O* as centre, and any convenient radius, describe an arc cutting the ellipse in *L*, *M*, and *N*. Join *L* and *M*, and *M* and *N*. Through *O* draw parallels *AB* and *CD* to *LM* and *MN* respectively. *AB* and *CD* are the axes. The foci [*F* and *f*] are found as in **377**.

383. TO DRAW A TANGENT AND A NORMAL TO AN ELLIPSE FROM A GIVEN POINT *E* IN THE CURVE. Find the axes and foci as in **382**. Join the foci with *E* and produce *FE* and *fE*. Bisect the angle *FEG* by the line *HJ*, which is the tangent. For the normal, draw a perpendicular, *KE*, to the tangent. Or, bisect the angle *GEL* by the line *KE* which is the normal.

The Parabola. This curve is the locus of a point which moves so that its distance from the focus [*F*, in **384**] always equals its distance from the fixed line called the directrix, *DD*. Thus $Fa = aL$, or $Fc = cM$. In **384**, *AB* is the *axis*, a line drawn through the *focus F*, perpendicular to the *directrix DD*, and meeting the curve in the point *V*, which is the *vertex*. *a*1, *c*2, etc., are *ordinates*; *aa′*, *cc′*, etc., are *double ordinates*; and *bb′* (through the focus) is the *latus rectum*. A part of the axis between the ordinate of a point and the vertex of the curve is the *abscissa*—*e.g.*, 3*V* is the abscissa of the point *d*.

384. TO DRAW A PARABOLA, THE FOCUS *F* AND THE DIRECTRIX *DD* BEING GIVEN. Through *F* draw the axis *AB* perpendicular to *DD*. Bisect *AF* in *V*, which is the vertex of the curve. Take any points 1, *F*, 2, 3, 4, etc., and through them draw the ordinates. With *F* as centre and radius *A*1 cut the ordinate in *a* and *a′*. With radius *AF*, and again the focus as centre, cut the ordinate through *F* in *b* and *b′*. With *F* as centre again, and radius *A*2, cut the ordinate through 2 in *c* and *c′*. Proceed in the same manner with any other points. Draw the parabolic curve through the points.

384A. TO DRAW A TANGENT AND A NORMAL FROM A GIVEN POINT *P* IN THE CURVE. Join *P* with the focus *F* [see **384**], and draw *PE* parallel to *AB*. Bisect the angle *EPF* by *HG*, which is the tangent. *PJ* a perpendicular to *HG* is the normal.

385. TO DRAW A PARABOLA, WHEN THE AXIS *AB* AND AN ORDINATE *BC* ARE GIVEN. Produce *CB* to *D* and make *BD* equal to *CB*. Construct the rectangle *CDFE*. Divide *AE* and *EC* into the same number of equal parts (say three). Join *A* to 1 and 2 in *EC*. From 1 and 2 in *AE* draw parallels to *AB* intersecting the other lines. Through the points of intersection draw the curve *CA*. Repeat the method for the other part of the curve, as shown.

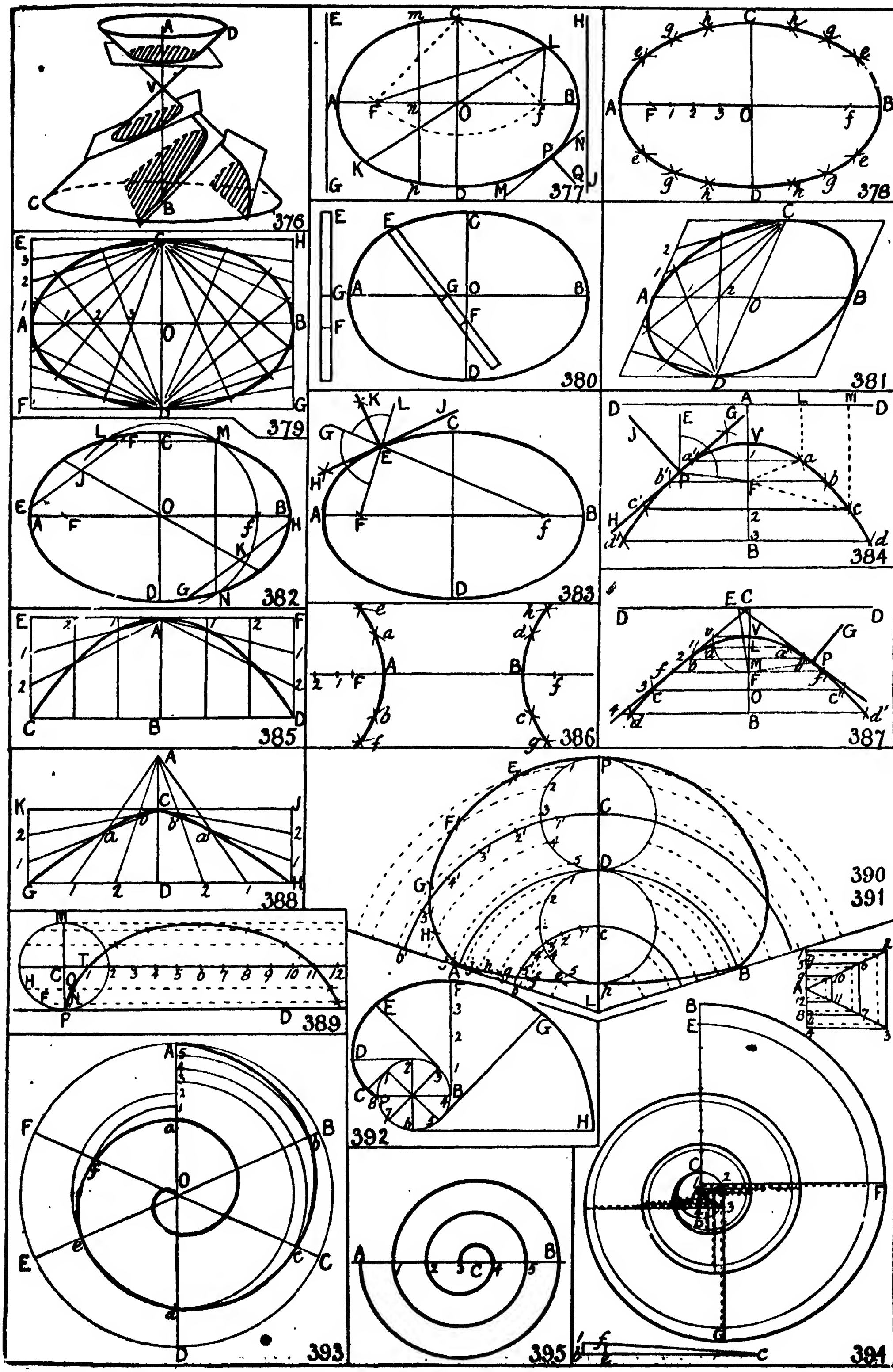
The Hyperbola. This curve is the locus of a point which moves so that its distance from the focus bears a constant ratio (greater than unity) to its distance from the directrix.

386. TO DRAW THE HYPERBOLA, WHEN THE MAJOR AXIS *AB* AND THE FOCI *F* AND *f* ARE GIVEN. In *AB* produced, and beyond *F*, take any number of points, 1, 2, 3, etc. (It is better gradually to increase the distance between the points, as shown.) With centres *F* and *f* and radius *A*1 describe arcs at *a*, *b*, *c*, and *d*. From the same centres, with radius *B*1, intersect the other arcs at *a*, *b*, *c*, and *d*. With centres *F* and *f* and radius *A*2 describe arcs at *e*, *f*, *g*, and *h*, and intersect them with radius *B*2 from the same centres. Proceed likewise with the radii *A*3 and *B*3. Draw the curve through the points of intersection.

387. TO DESCRIBE THE HYPERBOLA, HAVING GIVEN THE FOCUS *F*, THE DIRECTRIX *DD*, AND THE VERTEX *V*. AND AT A POINT, *P*, IN THE CURVE TO DRAW A NORMAL AND A TANGENT. Join *FV* and produce both ways. Draw *Vv* perpendicular to *CB* and equal to *VF*. Draw *Cv* and produce. On *VB* take any points *L*, *M*, *F*, *O*, etc., and through them draw the double ordinates perpendicular to *VB*, meeting *Cv* in 1, 2, *f*, 3, etc. With centre *F* and radius *L*1 cut the double ordinate through *L* in *a*, *a′*. With same centre and radius *M*2 cut the double ordinate through *M* in *b*, *b′*. Proceed similarly for the other points *f*, *f′*, *c*, *c′*, *d*, *d′*. Through these points draw the curve.

For the tangent, join *F* with the point *P*. Draw *FE* perpendicular to *PF*, and intersecting the directrix in *E*. Draw *EP*, the required tangent. The normal is *PG*, perpendicular to the tangent.

388. TO DRAW THE HYPERBOLA, HAVING GIVEN *AC*, HALF THE MAJOR AXIS, *GH*, A DOUBLE ORDINATE, AND *CD*, THE ABSCISSA OF THE POINT *G* OR *H*. Draw the rectangle *GHJK* about *CD* and *GH*. Divide *GD*, *HD*, *HJ*, and *GK* into any number (say three) of equal parts, and number the parts as shown. From *A* draw



376-395 THE ELLIPSE, PARABOLA, HYPERBOLA, CYCLOIDAL CURVES, SPIRALS, AND IONIC VOLUTE

lines to the points on GH, and from C lines to the points on GK and HJ. The intersections of $C1$ with $A1$ give the points a and a', and the other respective intersections give the other points b, b', through which the curve is drawn.

Cycloidal Curves. A *cycloid* is the locus of a point on the circumference of a circle, which rolls along a straight line, and always revolves in the same plane.

The *epicycloid* is the locus of a point on the circumference of a circle, which rolls along the *outside* of another circle, both circles remaining in the same plane.

When the circle rolls along the *inside* of another circle, both keeping in the same plane, the curve traced by the point is called the *hypocycloid.*

The moving circle is the *generating circle;* the line upon which it rolls is the *director;* and the point tracing the curve is the *generator.*

389. To Draw the Cycloid of the Point P in the Generating Circle PHM, which Rolls Along the Director PD. Divide the circumference into any number of equal parts (say 12). Through the divisions draw parallels to PD, and make the one through C (the centre of the circle) equal to the circumference of the circle. Divide this parallel into 12 equal parts. With 1 as centre and radius CP, cut the parallel through F in N. With same radius and centre 2 cut the parallel through H in O. Repeat the method with 3, 4, 5, 6, etc., as centres. Draw the cycloid through the points P, N, O, T, etc.

Note. If the point (generator) is not in the circumference of the circle, the locus is termed a *trochoid*, and is found in the same manner as the cycloid.

390. To Draw the Epicycloid, the Director ADB and the Generating Circle, the Point P being Given. Divide the circumference into any number of equal parts (say 12). Join L, the centre of the director arc ADB, with D, the point where the director touches the generating circle, and produce to P. DP is the diameter of the generating circle. Measure the arc DA equal to half the circumference of the generating circle; this is best done as follows: The angle DLA bears the same ratio to 180° as the radius of the generating circle does to the radius of the director. Thus, if $DC = 2$, and $LD = 5$, the angle $DLA : 180° ::$ $2 : 5$—*i.e.*, $5DLA = 360°$, or $DLA = 72°$. Draw LA making 72° with LD and produce. With centre L describe an arc through C. This arc is the path of the centre of the circle when rolling, and $6'$ is the position of the centre when P reaches A. Divide $C6'$ into six equal parts, $1'$, $2'$, $3'$, etc. With centre L describe arcs from 1, 2, 3, etc. From centre $1'$ with radius CD cut the arc from 1 in E. From centre $2'$ and same radius cut the arc from 2 in F. Proceed similarly for the other points G, H, and J, and also for the other half of the curve, which is to be drawn through the points A, J, H, G, F, E, etc.

391. To Draw the Hypocycloid when the Director ADB and the Generating Circle Dp are Given. Proceed exactly as in the preceding problem. Draw the half curve $_oAp$ through the points e, f, g, h, j, and A.

Miscellaneous Spirals. The *involute* of a circle is the locus of the extremity of a perfectly flexible thread unwound from a circle and kept constantly taut.

392. To Draw the Involute of a Circle. Divide the circle into any number of equal parts (say eight). At the extremity of each radius draw a tangent to the circle, and make the one BF from B equal to half the circumference of the circle. Divide BF into four equal parts. Make $1C = B1$, $2D = B2$, and $3E = B3$. Draw the curve through the points P, C, D, E, etc.

393. To Draw an Archimedean Spiral, the Longest Radius, OA, and the Number (say Two) of Convolutions being Given. Describe a circle with radius OA. Divide OA into as many equal parts as convolutions required (two). Divide the circle into any number of equal parts (say six), and draw the radii, OB, OC, etc. Divide Aa into the same number of equal parts (six). Make $Ob = O5$, $Oc = O4$, $Od = O3$, etc. Draw the first convolution through the points A, b, c, d, e, f, a. The second convolution is parallel to the first.

394. To Draw the Ionic Volute, the Cathetus, or Greatest Radius, AB, being Given. (Goldman's Method.) Divide AB into *nine* equal parts. With centre A and radius equal to one equal part describe the circle for the eye CD. Bisect AC and AD in 1 and 4, and construct the square 1 2 3 4. [See smaller figure.] Join $A2$ and $A3$, and trisect $A2$ and $A3$ with great care. Through the points of trisection 6, 7, 10, 11, draw lines to obtain the smaller squares, 5 6 7 8 and 9 10 11 12. With centre 1 and radius $1B$ describe the first quadrant to meet 1 2 produced in F. With centre 2 and radius $2F$ describe the second quadrant to meet 2 3 produced in G. Proceed in like manner for the other quadrants, being careful to take the centres successively as figured. An enlarged drawing of the construction is given.

The inner curve is obtained thus: Make $cb = CB$, and the perpendicular $b1 = A1$. Join c and 1. Make $be = BE$, and at e draw the perpendicular ef. From A (above and below), set off Ag and Ah each equal to ef, and construct the dotted square. Trisect as before for the smaller dotted squares, the corners of which are the centres for each quadrant of the inner curve.

395. To Draw a Spiral Scroll by means of Semicircular Arcs, having Given the Greatest Diameter AB and the Number of Convolutions (say Three). Divide AB into six equal parts in 1, 2, 3, 4, and 5. Bisect 3 4 in C. With centre C and radius $C3$ or $C4$ describe a semicircle. With centre 3 and radius 2 3 make another semicircle. Then with C and 3 as centres alternately, and radii $C2$, $C1$, and 3 1, $3A$, respectively and alternately, describe the remaining semicircles.

W. R. COPE

Milk and the Fine Foods Produced from it. The Strength and Stimulation Received from Cereals.

MILK AND BREAD

We have discussed the place of food in health; we now proceed to consider some of the chief foods in detail. Let us begin with milk, the most important, perhaps, of all nourishing foods.

Man is a mammal, and the first food he receives should be milk from his mother's breast. Failing maternal milk, he has to fall back on goat's milk or cow's milk, but milk he *must* have.

Seen with the naked eye, milk is a white fluid. Seen through the microscope, it is a clear fluid full of tiny drops of fat. Since it is the exclusive food of young mammals in the earlier months of their lives, it necessarily contains all the food constituents essential for fuel and building purposes. The figures in the following table give the proportions of the chief food constituents in human milk and cow's milk.

Constituents of Milk	Human	Cow
	Per cent.	Per cent.
Proteins	1·7	3·5
Butter (fat)	3·4	3·7
Lactose	6·2	4·9
Salts	0·2	0·7

Special Characters of Animal Milks. We see that there is considerable difference between the composition of human milk and bovine milk, and every animal's milk has its own particular composition. The differences are essential to the healthy nutrition of each particular mammalian infant. Hence, when we feed a human infant on cow's milk, efforts are made, by adding sugar and cream to the cow's milk, to render it more like human milk. No efforts, however, can make bovine milk human milk, nor cow's milk as good for a child as the milk of its own mother, and no bottle-fed child will ever thrive so well as a breast-fed child. Apart altogether from quantitative differences in the proportions of protein and sugar and fat, there are qualitative differences that cannot be remedied by any known methods.

Superiority of Mother's Milk. Bovine caseinogen (in proteins) and human caseinogen have been recently shown to be chemically different, and they form different curds in the process of digestion. Moreover, it has been proved that, no matter how we doctor cow's milk, it is never digested in the infant's stomach so rapidly as human milk.

A very important difference between cow's milk and woman's milk, not shown in the above table, is a difference in the amount of the protein compound of phosphorus known as "lecithin." Lecithin is found mainly in the brain and nerves, and is used in the building of these. In cow's milk only 1·4 per cent. of the total protein contents is lecithin, whereas in human milk 3·05 of the protein contents is lecithin. The amount of lecithin in the milk of any animal seems proportionate to the weight of the brain of the young animal, and by giving an infant milk with enough lecithin only for the brains of a calf we may be permanently weakening its brain and nervous system.

The salts, too, of potash and soda and lime and iron in the milk of any animal seem to be gathered from the blood in a very marvellous way, so as to correspond in their proportions to the salts in the young animal's tissues. Compared in respect of constituent salts, we find great differences between the milk of a woman and a cow, and an infant fed on cow's milk is not getting salts in the right proportion that his tissues require them.

Lately, too, the German scientist Ehrlich has pointed out that the mother passes over to the child in her milk any antitoxins against disease that she may have formed in her own blood, and so the child who is not fed on his mother's milk misses the chance to acquire immunity to certain diseases.

The Risks of Bottle-Fed Infants. So-called humanised milk is only a rough-and-ready imitation of human milk, and no infant can thrive as well on it as on a mother's milk. Apart from the question of mere nutrition, bottle-fed infants are exposed to the risk of poisoning from the various microbes that are liable, even despite care, to infect feeding-bottles, and are less able to resist any disease they contract. Thousands of children die every year simply because their mothers are unable or unwilling to suckle them, and, whether the reason be selfishness or feebleness, it is a terrible comment on modern civilisation—the highest of all mammalians unwilling or unable to give mother's milk to its own offspring!

Milk as a Tissue-Builder. Milk is especially a tissue-building food. The protein called caseinogen is the most marvellous tissue-building substance we know. In it are represented practically every substance that is used in building up the other proteins of the body. Fed only on milk, a rabbit doubles its weight in six days. Realising its building importance and their own small build the Japs are encouraging cow-keeping and milk-drinking.

Milk is therefore essentially the food of growing animals, but it is also one of the best foods that adult persons can take, and the almost universal use of milk, butter, cream, and cheese shows that the instincts of mankind have taught them its value. It does not, however, contain sufficient sugar and fat to supply in itself, unless taken in very large quantities, all the energy-fuel required by a vigorous adult,

but in combination with bread or porridge or farinaceous puddings it is sufficient food for a Samson or a Hercules. For invalids and bed-ridden persons it suffices for all purposes. And we must remember that it is one of the foods that stimulate digestive juices even when appetite is lacking.

Fat of Milk. The fat of milk is in the form of a fine emulsion, and when the milk stands fine globules of fat rise to the top of the milk, and are known as cream. Otherwise it may be separated off, as is done in dairies, by a centrifugal separator. The fat, in chemical character, is very like the fat of fatty tissue.

Minerals in Milk. The minerals in the milk are chiefly phosphate of lime, which is used for making bones, and phosphate of potassium, which is used for making muscles, but there are also sodium and magnesium salts and iron oxide. They are present in various proportions in animals to suit their various tissues.

The richness of a milk is judged by the proportion of fat it contains. It averages about 3·7 per cent., but may reach 4·7, or in Jersey cows as high as 7 per cent. Milk in which there is under 3 per cent. of fat is either bad or watered, and it is illegal to sell it.

How to Take Milk. When milk is swallowed, the first change that occurs in the process of digestion is the formation of a curd consisting of clotted casein. This clotting is produced by a digestive substance called rennin, and can be also produced outside the body at body temperature. Sometimes the clot formed seems specially tough and dense, and the digestion seems unable to proceed further with it. Tough curd can be prevented by diluting the milk with soda-water or lime-water, or by sipping it slowly and thoroughly insalivating it before swallowing it. Milk should not be gulped down; it is not so much a liquid as a solid food.

There is a great prejudice in favour of drinking milk between meals and avoiding it at meal-times, but it is really best to take it at meal-times, along with other food; and the fashion of drinking it at luncheon or dinner instead of beer is steadily spreading.

Some foolish people, forgetting their infancy and childhood, declare they cannot digest milk. That is usually a fancy. If milk has not been drunk for a long time there may be some deficiency of rennin, perhaps, but a little persistency will get over that. Milk is really a most easily digestible food, and, as Pawlow has shown, it not only by its own chemical character stimulates the digestive juices requisite to digest it, but it is digested with a smaller expenditure of gastric juice than any other food, so that altogether it is almost an ideal food.

Milk and Microbes. But milk has one very great drawback. It is a good food not only for baby boys and baby girls, but also a splendid food for microbes. Microbes that fall into it flourish exceedingly, and produce enormous, thriving families in a very short time. When milk stands uncovered for some time we know it becomes sour, and that is owing to chemical changes produced in it by bacilli that drop into it and flourish there.

The bacilli that turn milk sour are not harmful; sour milk is quite wholesome; but there are many others that drop into milk and multiply and spread disease and death. A few typhoid microbes may drop into a milk-pail, or a thirsty fly may bring them on its dirty feet, and they multiply in the milk, and may fill a whole village with cases of enteric. Worse still, the microbes of tuberculosis may drop in, brought by flies, perhaps, or coughed in by a consumptive dairymaid, or contributed by a diseased udder, and the result is that the children who drink the milk get tubercular glands and joints and lungs. Cows are often tuberculous, and 10 per cent. of London milk was recently found to contain living and virulent tubercle bacilli. Adults may also get tuberculosis in this way, but as a rule, the hydrochloric acid in their stomach kills the microbes. The children are the chief victims.

The Need for Boiling Milk. Unfortunately, byres and dairies are often very dirty; cows are often very badly kept, and milk-pails and milk utensils are not properly sterilised, so that every opportunity is given to disease germs to do their deadly work. Even under the best conditions and the most careful ordinary precautions milk cannot always be kept free from contamination, and it is safest and best to drink no milk that has not been boiled or Pasteurised. In most Continental countries milk is boiled as a rule. In this country boiled milk is the exception, but milk ought always to be boiled or sterilised. There is an idea that milk that is boiled is spoiled, or at least becomes less nutritious and less digestible. There seems some likelihood that boiled milk is not quite so easily digestible nor so nutritious as raw milk, but the same difference is found between raw and cooked meat, and yet we continue to cook our meat. Even if milk be rendered a little less nutritious and a little less digestible, it is better to put up with that than risk swallowing a few millions of disease microbes.

Goat's Milk. Goat's milk is sometimes used instead of cow's milk. It has more protein and more fat, but less sugar. The public, as a rule, have a prejudice against it, and think that it has a strong and disagreeable flavour, but if the goat be carefully fed its milk has practically no odour, and the fact that the goat does not suffer from consumption is a strong argument in favour of its milk.

Cream. Cream is mainly the fat of the milk, but it contains also protein, milk, sugar, and mineral matters. It is one of the most nutritious and valuable fats we know. Its value depends chiefly upon the facts that it very closely resembles the fats of the body, and has such a melting-point that at the temperature of the body it is just on the verge of melting. It is really a much more suitable form of fat for fattening and energising purposes than the well-known cod-liver-oil fat.

Skimmed Milk. Skimmed milk is the residue left when the cream has been removed; it contains most of the protein, but very little fat. It is, therefore, more useful for building than for working purposes, but if fat in some other form or carbohydrates be added to the dietary it is a most valuable and economical food.

Protein of Milk. The protein of milk, as we have said, is the best tissue-builder known, and contains every kind of brick, so to speak, that can be built into the edifice of life. It is quite easy to separate it from the milk, dry it, and use it in powder form; and many preparations of dry-milk protein, such as protene, casumen, sanatogen, and plasmon, are to be bought. Sanatogen contains, in addition to protein, 5 per cent. of glycerophosphate of sodium. These dry preparations of protein enable us to avail ourselves of the protein of milk in large quantities without adding too much fluid to the system, and in so far they are useful and good. They can be added with advantage to cereals and vegetables deficient in protein.

Butter and its Allies. Butter is made by churning cream which is beginning to turn sour. It is practically concentrated cream, and contains, like cream, fat, protein, and sugar. Like cream, it is one of the most digestible and nutritious of fats. Like all fats, it has a high fuel value, and one pound of butter yields over 2000 calories. It is very serviceable in cold weather to keep up the temperature of the body.

Butter-milk is very much the same as sour skimmed milk. It is the sour fluid left in the churn after the butter fat has been removed, and contains almost the same percentage of protein as pure milk. It has therefore considerable nutritive value, and the lactic acid it contains makes it a refreshing drink.

Margarine or oleomargarine is a butter prepared from animal fats. It contains the same percentage of fat as butter, is very similar in its chemical character, is equally nutritious, much cheaper, and keeps better.

Cheese. Cheese is the clot of milk compressed into a solid form. It contains on an average about equal parts of water, fat, and protein; but cream cheeses contain a larger percentage of fat, and different cheeses vary in their percentage composition. The nutritive value of cheese is very high: a pound of cheddar cheese contains all the protein and most of the fat in one gallon of milk, or twice as much nourishment as is contained in a pound of beef. Owing, however, to its concentrated character and the large quantity of fat it contains, it is not very readily digestible, even though it contain digestive ferments that aid in the digestion of other foods. It can be rendered more digestible by grating it, or by carefully masticating it. The flavour of cheese depends on chemical products generated by the bacteria that grow in them. These bacteria are said to "ripen" the cheese, and are often grown specially and added.

Next in importance to milk as food for man come the cereals. The most important are wheat, oats, maize, and rice.

The Dominance of Wheat. Wheat is the most valuable cereal grown. On it is built, in great measure, our modern Western civilisation. The wheatfields are the great factories where the sun is manufacturing energy for the dominant races, and these races owe their dominance largely to the energy supplied them by the wheat. Wheat is a better food than rice, and wheat-eaters must always be superior in mental and physical energy to rice-eaters.

In the United States alone there are more than 30,000,000 acres of wheat-land, and in Canada there are many millions more. So long as we can get wheat, we are fit to hold our place in the van of civilisation, but if ever wheat fail us we shall probably decline to a lower level of energy. It is strange to think that proud man should be so dependent on the grass of the field.

The Parts of a Wheat Grain. The grain of wheat consists of three parts, the *germ*, the *endosperm*, and the *bran*; and when the wheat grains are ground into flour, flours of different character can be prepared according to the proportions of *germ*, *endosperm*, and *bran* contained in the final product. The nutrient value, again, of the flour depends on the proportions in which these three parts of the grain are retained, for the germ contains most protein, the endosperm most starch, and the bran most mineral salts and cellulose.

As a rule, the germ is rejected because it contains a fat that is apt to turn rancid, and the bran is rejected because it makes the bread brown and coarse. The flour therefore produced by milling processes contains more starch, less protein, less cellulose, and less mineral salts than the natural grain contains. The diminution of the protein diminishes the value of the flour as a complete food, since it reduces the protein below the level necessary to sustain life, and processes have been invented to retain the germ, and thus include more protein.

Hovis flour, for instance, is a flour containing the germ. A ferment in the germ is destroyed by superheated steam, and the fat is also treated with superheated steam to sterilise it and prevent it from turning rancid.

The Mistakes of Millers. The efforts of millers, however, have been directed to obtaining a very white, starchy flour to please the eye of the ignorant public, with a consequent reduction of the nutritive value of the wheat. Not only so, but it has lately been discovered that the most refined white flours used in bread-making lack the substance "vitamine" which we have previously mentioned, and thus render those who consume them less vigorous and more liable to disease. In view of this fact a great endeavour was made a few years ago to persuade the public to eat bread made of the less refined *seconds* flour, which is darker in colour, and contains more protein and also "vitamine." Bread made of such flour was sold and is still sold under the name of "standard" bread. It is not so attractive in appearance as bread made of white flour, and, owing to the extra protein it contains, it is stickier and stodgier, but it

is better for the health and energy of those that consume it than the starchy white bread.

For and Against Brown Bread. Brown bread or whole-meal bread is better than refined white bread, in that it contains more protein, more salts, and vitamine; but, weight for weight, it contains much less nourishment than white bread, for it contains much more water and a considerable proportion of indigestible bran, which is not only indigestible but hampers the digestion of the starch and protein with which it is mixed. It is not an economical loaf for the poor, but it at least contains vitamine, and the bran leaves a rough residuum in the intestine, which stimulates the bowels and relieves constipation. The extra mineral matter it contains may be good in cases of rickets.

The Baking of Bread. The baking of bread renders it more digestible. The starch grains are burst and broken by the moisture and heat, and the sticky and dense mass of starch and protein is blown up and broken up by carbonic acid which is driven through it. The carbonic acid gas is usually a product of yeast. Yeast is added to the flour, and, acting on sugar in the flour, forms carbonic acid gas and alcohol. The alcohol is evaporated by the heat, but the carbonic acid gas bubbles through the bread, and makes it light and spongy.

But yeast is not always used. Aerated bread is aerated by means of water saturated with carbonic acid gas under pressure. When the pressure is reduced the carbonic acid gas bubbles through the dough, and blows it up. In other cases baking-powder, made of tartaric acid or bitartrate of potassium, with bicarbonate of sodium, is mixed with the dough, and gives off carbonic acid gas as in the case of an ordinary chemical reaction.

The Limitations of Bread. Bread as a food is deficient in two ways. In the first place, it has too little protein, and in the second place it does not, like milk and meat, excite the digestive organs to secrete digestive juice. Therefore it is best taken with meat, soup, or milk, or soaked in gravy. In any case, it should always be particularly well masticated, both because mastication provokes appetite-juice and because there is a ferment in the saliva which digests starch.

The Indigestibility of New Bread. New bread is very indigestible. It cannot be properly chewed and insalivated. A dry crust is much more digestible and nutritious. Toast is tastier than plain bread, but if it be soaked in butter, as it often is, it is rendered less digestible. A biscuit is a very good form in which to take flour. Biscuits contain, bulk for bulk, less water and more carbohydrate and protein than bread, and their very dryness ensures sufficient mastication and insalivation.

Macaroni, vermicelli, and semolina are preparations of wheat containing a large percentage of protein, and are very nutritious foods. Many patent foods have wheat as their basis.

Oatmeal Second Only to Wheat. Let us now look at oatmeal. If wheat be the best of cereals, oats are a good second. They have been defined as "the food of men in Scotland and the food of horses in England," and the definition has been followed by the very suitable retort, "Where else can you find such men and such horses?" The figures in the following table give a comparative view of constituents of wheat and oats.

	Water	Protein	Fat	Starch	Cellulose	Mineral Salts
Wheat	13·6	12·4	1·4	67·9	2·9	1·8
Oats	12·4	10·4	5·2	57·8	11·2	3·0

It will be seen that wheat is rather richer than oats in protein and carbohydrates, but that oats are much richer in fat than wheat, and have a much greater percentage of cellulose. The richness in fat renders oats a more heating food than wheat, and rather less easily digested. The large percentage of cellulose renders oats less nutritious, and rather irritating to the bowels. In certain cases of constipation, however, the large residue of cellulose is beneficial. Oats are usually taken in the form of porridge or oatcakes; they do not cohere into bread.

Quaker and Waverley Oats. Quaker Oats and Waverley Oats are flattened and crushed between heated rollers so that the cellulose is broken and the grains partially roasted. This treatment renders the oats more digestible, and the fat in the oats less liable to turn rancid. We must not forget to put to the credit of oats the fact we mentioned in a previous chapter: that the oats contain some mysterious substance that has a stimulating effect on the thyroid gland, and favours development.

Maize. Maize, or Indian corn, is as cheap as wheat and almost as nutritious and digestible, but it does not make into bread. Unfortunately, it is known in England chiefly as cornflour, in which form it has been deprived of its protein, and consists almost entirely of starch. It is a favourite food for invalids, but it is not suitable as an invalid food, and is much more fitted as fuel for a working man.

Rice. Rice is the most generally used of all cereals. It forms the staple food of one-third of mankind. Its composition is as follows: Water, 13·1 per cent.; protein, 7·9 per cent; fat, 0·9 per cent.; starch, 76·5 per cent.; cellulose, 1·6 per cent. It will be seen that rice is much poorer in protein and fat than wheat or oats, but much richer in starch. It has little flesh-building and little heat-producing material, and is thus suitable for lean men of moderate muscular development working in a warm climate. Almost the whole of it is absorbed, and it leaves very little intestinal residue. When polished it consists almost entirely of starch, and loses with its protein the substance called vitamine, which is necessary for health—so necessary that the abstraction of it from the rice results in the disease called "beri-beri."

RONALD MACFIE

Production of Milk, Cream, Cheese, Butter, and Preserved Milk. Dairy Cattle, their Management and Food.

DAIRY FARMING

In this country the production of milk for sale in its natural condition has become the most important feature of dairy farming, elaborate machinery, scientifically designed, being employed today. The limited size of our islands, with their population, practically forbids the production of all the butter and cheese we require for our consumption. Thus, while the importation of fresh milk is practically prohibited by time and temperature, the daily demands of the people make it imperative upon the farmer to abandon to a very large extent the manufacture of the two chief products we have named for what in most cases is the more lucrative practice of producing milk for sale. There is, nevertheless, still great scope for the production not only of more milk, but of more butter and cheese, and in each case of better quality.

The products of British dairy farming are:

1. Milk for sale. 2. Cream for sale. 3. Butter. 4. Cheese, which is manufactured in five forms—(*a*) pressed, (*b*) blue veined, (*c*) unpressed, (*d*) soft, (*e*) cream. 5. Condensed and other forms of preserved milk.

Separated milk is also sold in large quantities, and it is known to be largely employed as an adulterant of new milk.

Milk. Milk produced for sale varies in quality. In accordance with the Government standard, it must contain 3 per cent. of fat. The richest milk produced by farmers and others—that from Jersey, Guernsey, and Devon cows—seldom finds its way into the market; it contains from 4½ to 5½ per cent. of fat, individual cows often doing still better, and possesses greater value for butter production than the milk of other cattle.

Cream. Cream is sold in two forms: (1) that which is skimmed by hand or taken from the separator, and sold quite fresh or in jars; and (2) clotted cream, almost exclusively the production of Devon, Cornwall, and Somerset. This material, richer in flavour, having been submitted to heat, keeps under natural conditions much longer than cream skimmed by hand or by the separator.

Butter. The butter we produce varies in quality and character as much as in price, 7d. a pound being by no means uncommon in some markets during summer, while 1s. 6d. and still higher figures are often realised by skilled makers, oftentimes amateurs, as the production of a Jersey or a Guernsey herd. British butter may be divided into two categories, that which is produced on the farm, and that which is the product of the creamery or factory. The average samples of either are, perhaps, not superior to the best kinds imported from France and Denmark, but the best brands in this country, such as those exhibited at the National Dairy Show at Islington in October, are incomparably superior to anything we import. We are compelled to admit that our inferior brands of farm butter are less palatable than the uniform product of the Danes and the Normans, and it is for this reason that the character and the flavour of our best butter is practically unknown to the average consumer. The best imported butters are the factory brands of Denmark, and the best blended butters are those of France; following these in order come the products of Canada, Italy, Holland, Australasia, Germany, and Russia.

Cheese. Cheese is made in this country in great variety, although to a much less extent than in France. British cheese may be classed as follows.

PRESSED—Cheddar, Cheshire, Gloucester, Derby, Leicester, Lancashire, Wiltshire Loaf.

BLUE VEINED—Stilton, Wensleydale, Cotherstone, Dorset (chiefly skimmed milk).

UNPRESSED—Caerphilly.

SOFT AND CREAM.—Yorkshire Curd, Godmanchester, Colwick, Slipcote, St. Ivel (Yeovil), Coulommiers, Gervais, Pont l'Evèque (the three last-named are imitations of French articles), and cream.

The most important British cheese is Cheddar, which is the type of the product which reaches us in such large quantities from Canada and Australia and the United States. Cheshire of fine quality is largely consumed by the huge manufacturing and operative population of Lancashire, Yorkshire, and Cheshire. Leicester in its finest form is the most mellow of all British pressed varieties, but the art of making the best, if not lost, is now apparently but little practised. Stilton, made by a limited number of farmers, the majority of whom produce an inferior article, is practically on the market only during a limited season from December forwards, although it might and should be produced for sale during the whole year. Its superior quality as compared with the veined cheeses of the Continent, notably Gorgonzola, fits it for a lucrative and extensive export trade, but it is, even in our own country, superseded throughout the entire year by Gorgonzola of second and third rate quality hailing from Italy. Wensleydale, at its best, is equal to the finest Stilton produced.

Our curd and cream cheeses are much fewer and infinitely inferior to those produced in France, in which country the soft-cheese industry is of enormous proportions, enabling milk-producing farmers to realise much better prices than are obtained in this country, though the same results are possible. We are content to import Brie, Camembert, Roquefort—a sheeps' milk, blue-veined cheese—Pommel, a mixture of cream and milk curd; Port du Salut, which somewhat resembles our Caerphilly, although superior in quality, and other varieties, all of which it is possible for our people to produce with great profit to themselves.

Condensed and Preserved Milk. Condensed milk is now manufactured both from the pure and the separated milk of the cow, which also produces the raw material from which various brands of dried or powdered milk are manufactured. Beyond the fact that the farmer produces the milk for the manufacturer, the preserved milk industry has practically no relation to dairy farming.

Creameries. For many years the factory and creamery systems have been extending in all

dairy-farming countries, although in England, perhaps, least of all. The milk is contributed by the farmer, tested on its receipt. separated, the cream, in most well-conducted establishments, pasteurised, inoculated with a prepared starter containing the bacteria necessary for the production of flavour and quality, and subsequently churned in large quantities. Next to Denmark, which has led the world in this department of the dairy industry, Ireland is perhaps the most notable example of progress in the creamery system.

Value of Bacteria. The introduction of the *cream separator* more than twenty years ago by the Swedes and the Danes was almost contemporaneous with the inauguration of advanced dairying in this country; although followed by other inventions, it effected a practical revolution. Since that time the discovery that the flavour of butter and its keeping qualities are controlled by bacteria has enabled the maker to effect further improvements, so that the product of today, while far in advance of that manufactured by the past generation, will keep for a longer period. Much the same transformation has occurred with regard to cheese, which is now manufactured by all competent persons on the basis of scientific teaching.

Progress in one direction, too, has been accompanied by progress in another. The discovery of a method of manufacturing an imitation butter, known as margarine, by the aid of *oleo*, an important production of the Chicago stockyards, has led to its admixture with pure butter, and consequently to a form of adulteration which is now punishable by law, but which is often difficult of detection.

Sale and Yield of Milk. It is also instructive to learn that the farmer still sells his milk to the dealer, in spite of the existing law, by the barn gallon of 17 pints, practically 2 gallons with a pint overplus, which in earlier days was regarded as necessary to make up for the loss in retailing. Milk is usually sold under contract, realising a higher price from October to March than during summer, usually 1s. 8d. to 1s. 9d. per barn as against 1s. 4d. to 1s. 5d.

The dairy farmer's success depends almost entirely upon the productive powers of his cattle, and therefore upon his own skill as a buyer or breeder, and as a feeder. The average yield of milk in this country, as in America, is about 440 gallons per cow, which is an insufficient quantity to provide a profit. The fact, however, indicates that as there are large numbers of cattle which yield considerably more—from 1000 to 1200 gallons in individual cows, and from 600 to 700 gallons over whole herds—numbers of farmers must be owners of cows which yield considerably less than 400 gallons. The dairy farmer is more often than not a breeder of his own stock, and he should mate his cows with a bull of a milking strain, whose influence will assuredly result in the improvement of the milking properties of almost every heifer calf which is born to him; but this is made difficult in Great Britain by the fact that we have no system of recording individual milk production, and no milking herd-book record, such as is kept in the United States of America.

Feeding Principles. Economy in milk production may be effected in another direction. There is nothing in the management of a herd so important as a knowledge of the principles of feeding. To rely solely upon the common produce of the farm—hay, straw, and roots—is in these days absolute folly; yet there are many dairy farmers who use neither corn nor cake, or who, making purchases of both, employ them without recognising the principles upon which they should be selected.

Improvement in Dairy Production. Our third proposition relates to the exercise of greater skill in the production of butter and cheese. It is possible that less than 10 per cent. of our farm manufacturers of these two products are failing to obtain better prices owing entirely to deficient knowledge. Dairy schools exist, and itinerary instructors travel in many counties at the expense of the ratepayer; nevertheless, large quantities of English farm butter are sold week by week at much lower prices than are realised by imported brands, while the quantities of first-class cheese which are obtainable are so small, and of second and third class cheese so large, that one is almost inclined to despair of the future of British dairying.

Butter which realises 8d. per lb.—a very common price in summer—practically returns, allowing 1½d. a gallon for the skimmed milk, from 4d. to 4½d. per gallon, whereas when 1s. 2d. to 1s. 3d. is realised —and still better prices than these are obtainable for first-class Jersey or Guernsey butter—7d. per gallon may be obtainable. There are two reasons for this: the more perfect removal of the cream from the milk, and greater skill in manufacture. It is precisely the same with cheese. Many makers fail to obtain more than 50s. to 60s. per cwt. Others, equally clever in marketing as in manufacturing, obtain from 75s. to 85s., and in exceptional cases still higher figures, without adding the value of the whey.

Marketing. This question, which brings into prominence the business side of the farm, is one which is very much neglected. The farmer is seldom found circularising the public, or taking any steps by advertisement or otherwise to obtain regular customers with whom he may conduct a weekly retail trade. His cheese is sold to a merchant; his butter, more frequently than not, to a local shopkeeper, who is clever enough to obtain a profit upon what he buys as well as upon what he sells.

Among other subjects that may be briefly discussed here are some which directly bear upon the economy of the dairy. It is the custom in this country to house cattle during the night early in October, but it has been shown by demonstration at the Harper Adams College at Newport, in Shropshire, that where the cows are kept out of doors on the pastures at night to the close of the year, instead of bringing them in with October, money is saved. This is one among many questions which farmers should test for themselves, whatever their practice or belief may be. Again, in the rearing of young stock it has been demonstrated by the officers of the Yorkshire College that great saving may be effected by feeding calves upon skimmed separated milk to which cold-liver oil has been added in order to replace the fat that has been removed in the cream. During successive years groups of calves were reared to maturity, the accounts being strictly kept, on two systems of feeding, with *whole* milk and with *skimmed* milk and oil, and in each case the results were in favour of the latter.

The practice of town cowkeepers, who buy of the best that can be found, is to fatten each animal for the butcher as its milk supply decreases, with the result that there is a continual drain of the best cows in the country, very many of which are of high value as stock for breeding purposes. Whatever may be the practice, the principle is wrong.

Dairy Cattle. The pure breeds of dairy cattle which may be termed British are without question superior to those of any other country; indeed, with the exception of the black cattle of Holland, generally described as Dutch, the Schwyz of Switzerland, and the dairy cow of Normandy, all of which are excellent, we know of no cattle in the world which are approximately equal to the best of our native breeds. The foreign varieties that we have named, however, although large producers, yield milk which is only of moderate quality, and this especially applies to the Dutch cattle. Denmark possesses two varieties of dairy cow, the Jydsk and the Angeler, both useful and economical, while the Belgians own an excellent race in the Flamande; but these, again, can scarcely compare with the cattle of the British Isles, or with the best of France and Switzerland.

Improvement of Breeds. Unhappily, in all countries the majority of the cows kept by farmers are of impure blood, chiefly crosses or "scrubs," which have been carelessly bred, and in many cases carelessly reared. Whether purity of breed be maintained or not, in order to achieve success in the dairy farming industry it is essential not only to maintain but constantly to improve the milk-producing qualities, and this can only be accomplished by breeding farm-stock, both sire and dam, which is of essentially deep and rich milking blood. This fact may be illustrated as follows.

Purest, 15 lb. 4 oz. butter per week.	Mercury	Jupiter	Saturn, Rhea		
		Alphea	Saturn, Rhea		
	Nymphœa 18 lb. 7 oz.	Mercury, Phædra, 19 lb. 12 oz.	Mercury, Leda	Jupiter, Europa 15 lb. 6 oz.	Jupiter, Alphea

Cow A, 3 lb. butter per week	Bull 1	Bull 2		
		Cow C, 2 lb.	Bull 3, Cow D, 4 lb.	
			Bull 4, Cow E, 5 lb.	
	Cow B, 4 lb.	Bull 3		
		Cow F, 3 lb.	Bull 4, Cow G, 4 lb.	Bull 6, Cow I, 4 lb.
			Bull 5, Cow H, 3 lb.	Bull 7, Cow J, 3 lb.

Thus the cow Purest, bred from the bull Mercury (a son of Jupiter and Alphea, both of high butter-producing blood, as the pedigree shows) and the cow Alphea, which had already produced high butter-making stock when mated with Jupiter, produced $15\frac{1}{4}$ lb. of butter per week. Again we see by the second pedigree that by continually using cows which were small producers and different bulls, neither of which had any "butter blood," we get produce as in "Cow A," which shows a diminished yield of only 3 lb. per week. Whereas if these cows were mated in each generation to a bull with milking blood in his veins, they would systematically produce offspring which would inherit in a more or less marked degree the qualifications which their sires possess. It is for a similar reason that the constant employment of Shorthorn bulls, which have practically no inherent value except for the production of beef, while improving the size, form, and meat-producing qualifications of the stock to which they become sire, fails to impart the milking property which is so essential on the dairy farm. On the great majority of farms, calves are bred from time to time which are of little or no economical value for breeding or dairy purposes. Such animals should be converted as quickly as possible into veal, and this practice is more profitable when they arrive in the spring, and can be allowed sufficient milk at a time when its value is lowest in the market.

The Good Milking Cow. It is desirable, however, that we should not be mistaken as suggesting that milk is the only qualification in a cow. She possesses an intrinsic value apart from her deep and rich milking properties, and this is especially the case among the larger breeds. A good milker, therefore, should possess good feeding properties, a gentle disposition, a mellow skin, square build, which combines breadth across the hips and between the buttocks, depth of body, and length, although the milker, contrary to the beef-producer, is finer in the shoulder, neck, head, and horn. Size and constitution are largely obtained by the liberal feeding of the calf; and a lesson in this direction may be advantageously taken from those breeders of stock bulls who allow their bull calves to suck their dams, or to drink whole milk until they have completed their first year.

The best milk breeds are Dairy Shorthorns, Devons, Red Polls, Ayrshires, Kerrys, Dexters, British Holsteins, Jerseys, and Guernseys.

Management of the Cow. The student will find our general remarks on the Rearing and Management of Cattle on page 1885. We therefore confine ourselves now to the special treatment to be pursued in connection with the milking breeds.

In the ordinary way a milking cow should be dried six weeks before she is due to calve. In drying a cow, a milker begins by omitting a daily milking for a few days, and then by omitting to milk altogether. A week or two before calving—or when, owing to her breed or history, milk fever is anticipated—a cow of a fleshy breed should be scantily fed, that her condition may be reduced. If she be turned out, a poor pasture will serve the purpose best, without any addition to her ration. If she is being stall-fed, cake and meal should be omitted, a light ration of hay alone being provided, and she should have plenty of exercise.

Calving. When calving is near, the cow should be watched and kept untied night and day, either on a pasture or in a loose-box. Sometimes, after calving, the "placenta," or after-birth, refuses to pass, and a veterinary surgeon should then be called in.

It sometimes happens that after calving one of the teats of the udder is blocked, and refuses to pass milk. This is sometimes owing to a chill, sometimes to the carelessness of a milker before calving. It will need careful and gentle manipulation, and it may be necessary to strip it, or attempt to strip it, every couple of hours through the day in the effort to remove the material or cause of stoppage. Should hand manipulation fail, the calf should be tried. In the ordinary way, a calf will succeed where man does not, suction being powerfully brought to bear. Should there be no good result from either course, a silver tube must be obtained, and, after lubricating with oil, very carefully introduced into the duct of the teat. This will usually pass sufficiently far to enable the milk to flow, but the passage may close again unless the greatest possible care be exercised.

Another trouble is the hardness of the udder, which may arise from one of various causes. Here, too, the calf's assistance is often important; and although it is the practice of many breeders to remove the calf at birth, and to feed it from the pail, it had better be left with its dam in such a case, that, by its repeated sucking and punching,

the udder may return to its normal condition. Failing the calf, hand rubbing with oil or goose-grease is often found effectual, but in all cases the udder should be stripped of milk every three hours.

Colostrum. The first milk drawn from a newly calved cow is of much deeper colour than normal milk. It is known as *colostrum*, and is unquestionably valuable for the calf, upon which it acts medicinally. Colostrum is extremely rich in solid matter, especially casein and albumin. The solids may reach 25 to 28 per cent. against 13 in normal milk, while the casein and albumin may reach 15 to 20 per cent., against 4 per cent. in average milk.

Abortion, or slipping of the calf, is one of the accidents and misfortunes of the dairy herd. A cow purchased in the market or elsewhere may be infected, and, if the fact be unknown, may remain with the herd in her new home, and infect the cows around her [see page 2415]. No trouble should be regarded as too great in a case of this kind, for abortion in the herd has often ruined a farmer. A cow which has aborted should be fed for the butcher, as there is some risk of infecting the bull, and through him the whole herd.

Breeding. When a farmer breeds his own stock, he must decide at what age and under what conditions his heifers should be mated. A heifer which is undersized, raw, and still growing had better wait until from 19 to 21 months, but large-framed beasts, which are practically mature enough for breeding, may undoubtedly be introduced to the bull at 18 months. A heifer should never be retained for breeding if she be unhealthy, or, indeed, if she be not robust. It is far wiser to feed her for the butcher. Much is accomplished by good feeding from birth; maturity is hastened, strength is imparted, and an animal may be brought into the dairy as a profitable servant at the age of 2½ years instead of 2½ years or later. There are too many who fail to feed well, and who allow their young stock to graze upon poor pastures, in the belief that they are saving money by the practice. Ungenerous feeding is, however, uneconomical. In the case of the males of a herd, a young bull may prove infertile from time to time owing to the scanty way in which he has been fed.

In the vast majority of cases, cows calve in spring, but the farmer is able to control the period of calving in accordance with the value of the calf or of the milk. The cheesemaker, requiring milk from April to September, prefers the spring-calving cow; the milk-seller, who caters for winter prices, often prefers the autumn calver, and he may obtain a larger yield at a time when it returns him the most money. It is important, therefore, that where cows are to calve at given periods, the bull should be confined to a box and yard, and only used when the cows are in season and at the right date. Where the cows calve in spring, labour is reduced, together with the cost of feeding, for the herd, being on the pastures, are pretty much left to themselves. In winter, however, the milking cow is stall-fed, and this not only involves greater cost but demands greater attention at the hands of both owner and men. As we shall see, however, some hand-feeding in summer is important, and, indeed, imperative.

Points a Purchaser must Look For. It is important in purchasing a cow that no mistake should be made as to her value. There is no lesson in this matter which can compare with experience, but a few words will help even the experienced buyer. The animal [see page 1757] should be large for her breed, with a capacious belly, breadth across the hips, a straight back, depth of loin, width between the buttocks, fine shoulders and neck, a long, fine head, powerful muzzle, and fine, shapely horns characteristic of her breed. A short, thick cow with a deep brisket, coarse head and neck, heavy shoulders, and great fleshy character should be rejected, especially if the udder be small and narrow. She should be healthy, quiet, gentle, chewing her cud when at rest—a very good sign of health; her horns clean and without many wrinkles, her teeth sound (worn teeth and wrinkles on the horn indicate age), and provided with a well-formed, large udder with a silky covering much shrunken after milking.

The size of the udder is not an absolute guide to milking power, and therefore in purchasing from a private buyer on the farm it is wise to see selected cows milked morning and night, and to take the precaution not to inform the seller when a visit for the purpose will be made, or the animals may possibly be "stocked" for the purpose—that is, unmilked at the previous milking time. A good cow milks well to the last: nevertheless, a very heavy yield with one calf may be followed by a much lighter yield with the next, although later the return is almost certain to be good. There is no empirical method of selecting a good milker. The best judges are often deceived by appearances. A healthy cow has warm ears, a loose, mellow skin, horns warm at the base, and dew on her nose. It should be noted that a cow always grazing pushes her teeth through more rapidly, whereas fed in the stall she has less use for her incisors, which may in consequence appear later.

Care of Stock. Although the practice is most uncommon, cows should be daily groomed, scraped in winter, and washed, if necessary, to keep the flanks and buttocks clean. Apart from grooming, the coat should be washed at least once a week with soap-and-water, to which a small quantity of carbolic acid has been added. One part in fifty will destroy parasitic life. Should ringworm appear in cow or calf, immediate and persevering attention should be given, few complaints being more obstinate. The edges of the crust of the growth may be removed a little at a time, and the whole daily rubbed with carbolic or mercurial ointment, which, however, fails to penetrate the crust itself.

The Byre. The buildings in which cows are stalled, milked, and fed vary in design. They are described on page 2811.

The cows may be tied to the stalls in one of many ways. A common plan is to affix a vertical iron rod right and left with screws at each end to each partition. A chain is attached to this rod by a ring that it may slide from top to bottom, and thus each cow is fastened when the chain is passed around her neck to the partition next to which she stands, and is able to feed from the manger without too close contact with her neighbour. Food receptacles, however, whether manger or rack, are provided in numerous forms, and the remark equally applies to the various methods of changing the cows, especially in the United States, where they are in many cases most ingenious. An advantage of the firebrick manger is that if a tap be fixed at one end, and a pipe and plug at the other, the whole may be flushed out with water and cleaned, while, when necessary, it may be partially filled with water for drinking.

The walls of the cowhouse should be periodically lime-washed, and the floors disinfected daily;

where the latter are made of burnt clay or firebrick, and grouted in cement, they should also be flushed with water. In winter the stalls may be littered with straw—oat straw is best, especially as a portion will be consumed by the cattle—with peat moss, or even with sawdust or shavings, if other materials be not obtainable, although the latter do not make the best or most desirable of beds.

It is essential that boxes should be provided for calving cows, calves, and sick cattle, all of which should be well lighted and ventilated, but kept free from draughts.

Storing and Preparing Cattle Fodder. A food store and mixing apartment where a number of cows are kept is required, and it is a good plan to construct this in the centre of the cattle building. The floor should be of concrete, and arranged so that the pulped roots, the chaff, the cake, and the meal or grains used may be close at hand, ready for mixing in a heap morning and night. The mixture is usually allowed to remain heaped for twelve hours that it may ferment. Being thus warmed, it is carried, either in tubs or baskets, a galvanised iron barrow, or a tramcar, direct to the cattle.

Where many cows are kept the small steam or oil or petrol engine described on page 2812 may be used with advantage. There should be a loft or store overhead, and here the chaff-cutter may be fixed, the hay or straw being delivered from the outside of the building, and the chaff, as it is needed, passed below through a trap-door in the floor. A belt attached to the shafting which drives the chaff-cutter will serve to drive the pulper and the corn-mill; hence if a store for roots be conveniently placed, into which they may be delivered by the carts from the field, and if the grain to be ground be stored in the loft, the food may be conveniently prepared and mixed as occasion requires.

When and How to Milk Cows. Cows should be regularly milked, whatever the hours fixed may be, but it has been shown by experiment by milking at three periods—6.30 a.m. and 2.30 p.m., 6.30 a.m. and 4.30 p.m., and 6.30 a.m. and 6.30 p.m. —that although the yield was practically the same in each case, the mixture was richer when drawn at the first two periods. Except when milked twelve hours apart, or thereabouts, the milk of the evening is always richer than that of the morning. Milkers should be encouraged to milk with dry hands, otherwise the practice of dipping the fingers into the pail is regularly followed. The practice is not only disgusting but contributes to the non-keeping power of the milk thus contaminated.

When the milkers enter the cowhouse early on the winter's morning, the cows may be supplied with a little sweet hay or, if the owner prefers, with their morning's mixed ration. The udders are then cleansed, the milkers wash their hands, don their overalls, and draw the milk in pails which have been cleansed overnight and left in the air. After milking, and when the food has been consumed, the cows may be turned out either to graze and drink, or, when the weather is severe, for exercise and drink. After breakfast the men proceed to clean out the stalls, gutters, and houses, and then to prepare the ration for the following day. In summer the cows remain in the fields, but attention should be given to gates, fences, the water supply in ponds or streams, to possible gaps in hedges, and, where forage crops, such as vetches, rye grass, trifolium, clover, lucerne, cabbage, or maize are provided, to the cutting of the food and its conveyance either to the pastures where the cows are grazing or to the mangers. It will usually be found essential to allow the forage mown in the morning to remain until the next day before it is supplied, that it may lose part of its moisture, otherwise hoven [see page 2416] may follow, especially when this form of feeding is begun and when the food is young and succulent.

Necessity for Keeping Records. The system of recording the milk yield of each cow should be followed on every farm. There is no other method of ascertaining her intrinsic milk value. As the milk is drawn from each animal the pail should be placed upon a scale, the net weight ascertained, and marked on the record-sheet on the wall. A glance at such a sheet daily will suffice to satisfy an owner, or to indicate, when the yield suddenly falls off in a particular case, whether the cow be in season or suffering. The practice of measuring is misleading, and should never be followed; weight is the only certain factor; and a gallon may be estimated as weighing 10 lb.

Food for Dairy Stock. In supplying food to the cow, it is more advantageous, because more economical, to provide a mixed ration, where the animals are stall-fed, than food of one particular kind. Grass is the most important food of the cow, and it is important in proportion to its quality and variety. The term is applied to the herbage growing in pastures and meadows, and is therefore a mixture of many plants. Although cows may graze during a large part of the year, the herbage is more or less abundant only between May and October; and unless the land be overstocked it is during this period that they improve in condition and yield the largest quantity of milk. The value of grass, like hay, depends largely upon its richness in digestible albuminoids, and the proportion of these materials present in a sample is greater when the grass is young. It is commonly necessary to supply cows either with green forage crops to supplement grass or with meal or cake in order to increase the amount of albuminoids in the food.

Hay. In many parts of England hay forms the principal part of the winter ration. As we have seen, it varies in quality with the age and character of the grasses from which it is made. Good hay is the best balanced of all dry foods. Owing to its fragrance and sweetness it is agreeable to stock, and from this point of view cannot be replaced, but for the production of butter and cheese it is inferior to grass.

Forage Crops. These crops, without exception, are less well balanced than grass, and therefore less useful when supplied alone. Unless they be mixed, as where oats or rye are grown with vetches, they should be supplemented with cake or meal to prevent loss by waste. Foods like lucerne, vetches, and clover, which are exceptionally rich in albuminoids, should be supplemented by a dry food rich in carbohydrates, while foods like green maize, rye, and cabbage should in their turn be supplemented with a rich albuminous food like cotton-seed meal, bean-meal, or pea-meal [see table, page 2678].

Leguminous Crops. Among the leguminous crops which are most suitable are lucerne, sainfoin, vetches, and the clovers. *Lucerne* [page 2676] should, however, be given with food rich in starch. *Sainfoin* yields 15 tons to 17 tons per acre, and is twice cut. Like lucerne, it makes superb hay, and is suitable for cows,

especially when rice-meal or maize-meal is added. *Vetches* or *Tares* are only once cut, although when cut early a small growth follows. The winter vetch seed, mixed with oats or rye, provides a more suitable food for cows, coming early in spring, when they may be followed by spring vetches, which are good in late summer and autumn. Like all similar succulent forage plants, the vetch should be cut a day before using. The various *Clovers* [page 2676] should be mixed with grasses or fed on the pastures, or, if in stalls, supplied in conjunction with meal rich in starch.

Roots and Tubers. Of these the *Mangel* [page 2677] is the most important, although it is generally supplemented by the swede in North Britain. From 20 lb. to 50 lb. daily may be supplied to each cow from January onwards. The yellow tankards and globes are preferable to the long reds.

Swedes and *Turnips* are commonly used for dairy stock. The approximate percentage of dry matter in sugar in the various bulbs referred to is shown by the following figures, the result of the work of the late Sir Joseph Gilbert.

Roots	Dry matter per cent.	Sugar per cent.	
		In fresh roots.	In dry matter.
White turnips ..	8·0	3½ to 4½	44 to 53
Yellow turnips ..	9·0	4 to 5	44 to 56
Swedes	11·0	6 to 7	55 to 64
Mangels	12·5	7½ to 8½	60 to 68

Swedes and turnips may be pulped, sliced, or cooked for mixing with the cow's ration of chaff, greens, and meal.

Kohl-rabi is but little used, although those who grow it for cows speak of it in high terms. It keeps well throughout the winter, and communicates no ill flavour to the milk.

Probably owing to its sweetness, the *Carrot* is much relished by milking cows. Owing to the richness of the carrot in carbohydrates, it should be supplemented, when supplied in large quantities, by foods, such as cotton-cake, which are rich in albuminoids. The crop, when carefully stored, keeps well through the winter. The leaves may be fed with advantage.

The *Parsnip* [page 2677] provides 12½ per cent. of digestible dry matter in its roots, 11½ per cent. in its leaves, of which in each case about 10 per cent. are carbohydrates and 1¼ per cent. albuminoids. It keeps well, but is not so much relished as the carrot.

The *Potato* crop, when abundant and cheap, is frequently employed, either cooked or raw.

Concentrated dry foods are chiefly the by-products of the milling of grain, oil extraction from seeds, and the manufacture of sugar, starch, and alcoholic drinks.

The Right Use of Different Cakes. *Linseed Cake* is more useful for mixing with *cotton-cake* than for employment alone. It is of high value in the rearing of young dairy-stock. The product of the cotton-seed is used in three forms for cows—as meal, decorticated cake, and the common or undecorticated cake. The last-named is highly fibrous, and, if less costly, is much less economical. The meal and the best cake are highly relished by cows, are of great value for milk and butter production, and are believed to make butter firmer than any other food.

Rape Cake possesses a disagreeable flavour, although very rich in feeding matter. Owing to the small demand, its price is low, but when used for cows patience must be exercised in inducing them to eat it readily. *Soya-Bean Cake* has a high feeding value, but tends to make the butter soft. Another useful food, but little used in this country, is *Palm-nut Cake*, which is readily eaten by cows and is extremely rich in oil.

The Feeding Qualities of Meals. *Bean-meal* is highly nutritious, and useful for employment with roots, cabbage, straw, inferior hay, rice, or maize-meal. *Pea-meal* is richer than bean-meal, and may be similarly employed. English peas, however, like English beans, are usually too costly for cows; hence imported pulse is employed. *Lentils* are frequently placed on the market, and, if poor in oil, are rich in the other feeding constituents.

Rice-meal is extremely rich in starch, and should be used on that basis alone. *Gluten Meal* is a residue in the manufacture of starch from maize. This is an American product, of high value when pure. *Bran* [page 2679] is a valuable addition to the ration of the cow. *Sharps* or *coarse pollards*, like *middlings*, which are still finer, but richer in starch, are both useful foods when prices are low, and, although less laxative, they are as rich and as sweet as bran. *Maize-meal* is a highly concentrated and valuable food, largely used when the price is low. Compared with the oat, it contains 50 per cent. more feeding matter, weight for weight, when prices are identical. Maize-meal is especially valuable when cows are fed upon hay, herbage, or forage crops unusually rich in albuminoids. *Maize Germ Meal* is rich in all the feeding constituents, and is a very useful addition to the ration.

Oats, although a costly food, owing to its low weight, its price per bushel, and the proportion of husk or fibre, is most valuable for milk production.

The Best Ways of Using Grains. *Grains* are obtained from distillers and brewers in a wet, and from merchants in a dry or desiccated, form. They mix well with chaff and other foods. *Dried grains* may be used with confidence and success if the water be carefully added a day before they are to be used. Brewers' grains are richer in phosphoric acid and lime than the barley from which they are produced. *Malt Culms, Germs*, or *Sprouts* are the small, dead radicles of barley which has been malted. They are sweet, of agreeable flavour and odour, and well adapted for mixing with chaff and pulped roots.

Straws, their Qualities and Uses. The *straws* of cereals and pulse are of high value, inasmuch as they provide the padding which is so essential in the feeding of an animal with such a capacious stomach as the cow. The best straws are oat and pea, but wheat, bean, and vetch straw are sometimes used. All straws are preferably chaffed or chopped for mixing with rations. The chief feeding constituents are the carbohydrates and the cellulose, of which about one-half are digestible in the cereals and slightly more in the pulses. The pulse straws not only provide more feeding matter, but they are richer in albuminoids.

JAMES LONG

The Paraffins and their Derivatives. Varieties of Alcoholic Fermentation. The Sources and Uses of Alcohol.

THE PARAFFINS AND ALCOHOLS

Ethane. After methane we have to study ethane, which is the next simplest compound of carbon and hydrogen. This already illustrates for us the remarkable power which carbon possesses of combining with itself. The formula of ethane is C_2H_6. This empirical formula, however, tells us nothing as to its constitution. It can be obtained from a product of methane by a method which we have not space to consider, but it consists of two groups of atoms which have the formula CH_3. This group, or radicle—radicle, of course, means a little root—is known as *methyl*, and ethane may therefore be called dimethyl, since it consists of two methyl groups. Instead of using the empirical formula we may write what is called a constitutional or rational formula, in a fashion which clearly expresses the constitution of the molecule—thus:

$$H_3C\ CH_3.$$

Evidently this expresses much more than the mere empirical formula, nor is there any need for us to take the matter a stage further and use up space in figuring the graphic formula, since the reader can construct or imagine this for himself. He will then notice an illustration of the remarkable fact that one carbon atom can combine directly with another within the molecule.

The Paraffins. Ethane is a colourless, odourless gas resembling methane, and burning with similar products. From it there can be produced, in a fashion similar to that which led to its own production, another body having a similar type of constitution. In fact, there is a whole series, probably an endless series, of such hydrocarbons that have been produced by synthesis, and that are one and all models upon methane. The first four members of the series are colourless gases; subsequent members are colourless liquids; and higher members still are white solids. These bodies are remarkably free from tendency to chemical action. They have little tendency to combine with other elements. The ordinary oxidising agents do not affect them, and thus, since they are almost without affinity, they are known as the paraffins. The following is a list of the first few members of this series:

Methane, CH_4	Hexane, C_6H_{14}
Ethane, C_2H_6	Heptane, C_7H_{16}
Propane, C_3H_8	Octane, C_8H_{18}
Butane, C_4H_{10}	Nonane, C_9H_{20}
Pentane, C_5H_{12}	Decane, $C_{10}H_{22}$

etc., etc.

This extremely instructive series teaches us various things. It gives us a hint of the systematic character of the compounds we are now studying. Its higher members illustrate in an extraordinary way the power possessed by carbon of combining with itself. We observe in this homologous series, as it is called, that the difference between any two successive members is always CH_2. Further, we notice that there is a constant ratio between the number of hydrogen atoms and the number of carbon atoms. The former are always twice the number of the latter plus 2. Hence we can make a general formula for the whole series of paraffins, using the letter "n" to indicate the number of carbon and hydrogen atoms. This formula evidently will be

$$C_nH_{2n+2}.$$

Our study of the composition of the paraffins will suffice to explain why the higher members of this series are so extremely valuable as sources of light, heat, or other forms of energy. Obviously the whole of their substance is oxidisable; they contain no oxygen whatever, in the first place; and they contain an extremely high proportion of hydrogen, which is the most effective of all fuels.

Products of the Paraffins. We must now embark upon a long voyage in order to make the acquaintance of a whole host of important compounds which are derived from the paraffins. But we shall not encounter any very great difficulties if we keep the graphic formula of methane clearly in our heads. It really contains the key to all that is to follow.

The Paraffins and the Halogens. Among the simplest derivatives of the paraffins are those in which atoms of the halogens are substituted for atoms of hydrogen. Of these we have already seen several examples. Now we have to learn that the paraffins agree with one another, not only in the fundamental characters of their architecture, but also in the manner in which they form compounds. Thus, where methane forms compounds, ethane does so likewise. For instance, it is easy to obtain from methane a body which is, so to speak, a hydroxide. One of the hydrogen atoms of the methane has been replaced by the hydroxyl group, giving us the body with the formula CH_3OH. This may be called methyl hydroxide. And if it were a hydroxide we should expect that when it is treated with an acid there should be formed a salt and water, just for all the world as if the hydrocarbon were a metal. This is what happens, and we find that just as sodium hydroxide and hydrochloric acid yield sodium chloride and water, similarly methyl hydroxide and hydrochloric acid yield methyl chloride and water. If we merely remind the reader that methyl chloride has the formula CH_3Cl he will be able to write for himself the equation representing this action. Methyl chloride may also be produced by the action

of chlorine on methane when a mixture of them is exposed to light.

Now we find that ethane behaves in precisely the same way. The direct action of chlorine upon it converts it into chlorethane or ethylchloride, which has the formula C_2H_5Cl. And when the hydroxide of ethyl is treated with hydrochloric acid, the same substance is similarly produced. In this last sentence we have casually referred to one of the most important substances in the whole world, ethyl hydroxide, which we must discuss at length hereafter, and which is commonly known as *alcohol*.

The Alcohols. If we conceive of the paraffins as similar to metals, we are prepared to understand their possession of hydroxides. Each of them has its own hydroxide, one atom of hydrogen having been replaced by one hydroxyl group. These hydroxides are called alcohols, and therefore the first fact which we have to learn is that, properly speaking, alcohol is a general chemical term for a very large number of compounds. Just as there are lower and higher paraffins, so there are lower and higher hydroxides of the paraffins, or lower and higher alcohols. The first alcohol is, of course, methyl hydroxide or methyl alcohol; the second is ethyl hydroxide or ethyl alcohol; and it is this which is of such importance to man. The alcohol derived from propane is, of course, propyl alcohol. That derived from pentane is usually known as amyl alcohol, and has, of course, the formula $C_5H_{11}OH$. The presence of this and other higher alcohols in alcoholic drinks is of the utmost practical importance, since it leads to very serious symptoms in consequence of the rapidly poisonous and deliriant action which certain of these bodies possess. Methyl alcohol is of comparatively small importance. When we come to consider the next set of derivatives of the paraffins we shall see, however, that a substance derived from it is of great interest in relation to certain of the fundamental facts of life. Meanwhile, however, we must consider the alcohols.

Preparation of Alcohols. If we desire to prepare an alcohol, we find that it may be obtained from the corresponding halide, just as sodium hydroxide may be obtained from sodium chloride. For instance, water, under certain conditions, reacts with ethyl iodide, the hydroxyl of the water takes the place of the iodine atom, with the result that ethyl alcohol and hydriodic acid are formed. The equation for this is as follows:

$$C_2H_5I + HOH = C_2H_5OH + HI$$

There are many other fashions in which alcohols may be obtained, but we may content ourselves with afterwards discussing the method of Nature, which depends upon fermentation.

There are various kinds of alcohols, which are called *primary*, *secondary*, and *tertiary*, but their particular characters need not be discussed, nor yet the details of their derivation. The alcohols in general display a sequence of characters, as might be expected from analogy with the paraffins. Sir William Ramsay says: "The lower members of the series are mobile, colourless liquids, with but faint alcoholic smell, and mix with water in all proportions. The middle members are oily and have a heavier smell, and are sparingly miscible with water; and the higher members are insoluble, colourless, crystalline solids. The tertiary alcohols melt at a much higher temperature than do the primary and secondary."

Wood Spirit. The common name by which methyl alcohol is known is *wood spirit*, since it is obtained by the distillation of wood. This, however, yields many other products, such as water, vinegar, creosote, and tarry matter. In order to obtain it separately, calcium carbonate is added to this mixture, so as to combine with the vinegar; then when it is distilled, methyl alcohol and water are obtained. It boils at about 66° C. It is extremely inflammable, and is used as a source of heat, and, like ethyl alcohol, as a solvent, especially for resins.

When methyl alcohol is oxidised it follows the rule which, as we shall see, obtains generally of the series to which it belongs, and yields an acid. This is formic acid.

Methylated Spirit. This familiar product consists of a mixture of ethyl alcohol with 10 per cent. of methyl alcohol. The idea is to obtain a substance having the essential properties of ethyl alcohol but so disagreeable to the palate that it would not be drunk. This substance is now over half a century old, and, needless to say, has been very largely used for the purposes for which it was intended—as a solvent, as a preservative, as a source of heat, and so on. It is the lamentable fact, however, that, despite its disagreeable character, it has not infrequently been employed for the purpose of producing intoxication. It should really be made decidedly more disagreeable than it is. The common form of methylated spirit contains a good deal of petroleum oil as an impurity.

This, however, is the time at which one cannot too strongly insist that the device of preparing methylated spirit is totally inadequate to meet the present needs of this country. Probably the most productive and valuable of all the uses of ethyl alcohol depend upon its purity or comparative purity. The consequence is that the manufacturer in this country is ridiculously handicapped; he has to pay shillings where his German rival pays pence, and the consequence is that the manufacture of drugs, perfumes, etc., is handicapped in this country to the point of extinction. It is high time that we really had scientific taxation which would prevent us from strangling our industries in the process of collecting money for the purposes of revenue. Methylated spirit does not meet all the needs, and it is absolutely necessary that ethyl alcohol should be obtainable for manufacturing purposes without the payment of the heavy duty which is rightly placed upon it when it is used or abused in order to please the palate and nervous system.

Ethyl Alcohol. The formula of ethyl alcohol may be written in many ways, each of them varying in the amount of information which it affords. The empirical formula is C_2H_6O.. While this correctly indicates the number and character of the atoms in the molecule, it really tells us nothing as to the manner in which they are built up. The formula C_2H_5OH is much superior, since it indicates that the substance is a hydroxide, but the formula CH_3CH_2OH is better still, since it indicates the structure of the molecule in still more detail. Indeed, we have only to transpose the first and second terms in order to have the means of constructing the graphic formula of ethyl alcohol completely before us.

Fermentation. Fermentation is, of course, a very large term, indicating a whole host of actions. In general, we mean by a ferment an organic substance of animal or vegetable origin which has the power of inducing chemical change in other bodies without undergoing any change itself. Here we cannot discuss the problems which that involves, but must merely consider the facts of the commonest kind of fermentation, which is alcoholic fermentation of sugars. This process has long been known. The first age at which man prepared alcohol is far earlier than any recorded history. We know for certain that wine and beer were offered to the dead in Egypt in the fourth millennium before Christ, and there is other conclusive evidence to show that wine was prepared earlier than the fifth millennium before Christ. But it is only within a few decades that we have learnt the most remarkable and significant facts of the chemistry of fermentation.

Alcoholic fermentation takes place in the presence of the yeasts or saccharomycetes, also known as torulæ. It is not the yeast itself which brings about the decomposition of the sugar, but an enzyme, as it is called, which is present in the yeast cell, and which can be extracted from it by suitable processes. During the fermentation of the sugar the yeast multiplies rapidly, by the process of forming buds on its rounded cells (gemmation), and forms a scum on the surface of the fermenting fluid. There are definite limits of temperature within which the process can occur, and there is also a point at which the production of alcohol arrests the fermentative process by interfering with the life of the yeast plant. The historic discovery that alcoholic fermentation is caused by a living creature is an important link in that great chain of discoveries which led to the similar discovery of living microbes as the causes of fermentation, inflammation, and putrefaction in the body—thus leading to antiseptic surgery and its magnificent consequences, which have enabled a writer with a nice sense of antithesis to say that Lord Lister "saves more lives every year than Napoleon took in all his wars."

The yeast plant is found practically everywhere. We thus take it in large quantities with our food, but it is rapidly killed by the healthy stomach, which produces that powerful antiseptic hydrochloric acid. In those cases of indigestion where the production of this acid is defective, the yeast plant is enabled to multiply and cause alcoholic fermentation of the sugar of the food. This, of course, deprives the sugar of its food value and produces a quantity of gas, which causes discomfort and tends to stretch the walls of an already over-stretched stomach.

If a solution of sugar be exposed to the air—and the same is true, of course, of jam and many other substances containing sugar—specimens of these plants soon drop upon it from the atmosphere and undergo development. The essential change of alcoholic fermentation is the formation of ethyl alcohol and carbon dioxide from grape sugar. This body is a carbohydrate, and has the formula $C_6H_{12}O_6$. The reader should write out, for practice, an equation representing the decomposition. He will find that one molecule of grape sugar yields two molecules of ethyl alcohol and two molecules of carbon dioxide.

Sources of Grape Sugar. The technical name for grape sugar is *glucose*. It is by far the most important of all the carbohydrates, since it is the subject of alcoholic fermentation, and since it represents the form in which all carbohydrate foods are utilised by the animal body. It is the characteristic sugar of grapes, and, indeed, of fruits in general. But it is also obtained indirectly by transformation of other sugars. There is, for instance, another sugar with which we are most familiar, called *cane sugar*. This has to be changed into glucose—involving, as we shall see later, merely the insertion of a little more water into its molecule—before it can undergo alcoholic fermentation. It is the sugar of molasses. From fruits we obtain such alcoholic liquors as wines and brandy, while from molasses we obtain rum. But there is yet another carbohydrate which is a very important source of glucose, and that is starch. This is abundantly contained in such vegetables as potatoes and barley. It has the empirical formula $C_6H_{10}O_5$, being thus not very remote from grape sugar in constitution. An enzyme called *diastase* has the power of converting starch into grape sugar, and various alcoholic drinks are thus prepared, such as whisky and beer.

Alcohol and Bread. It will have occurred to the reader that surely alcohol must be produced in the making of bread, since all the necessary materials are present; and this is so. Indeed, bread owes its rising to alcoholic fermentation, since it is the carbon dioxide thus produced that gives the bread its characteristic texture. The whole, or practically the whole, of the alcohol produced evaporates and is lost. Extraordinary calculations have been made as to the monetary value of the alcohol which is thus produced and lost in the course of the manufacture of bread. In the making of so-called "aerated bread" yeast is not employed, and the carbon dioxide which is necessary in order to give the bread lightness is forced into it from without.

Making Wine. The principle of the manufacture of wine is simply to induce fermentation

in the juice of the grape. The necessary yeast plant can be abundantly obtained from the skins of the grapes themselves. The process of fermentation has its own natural limit, and therefore the product is run into casks. In the case of effervescing wines the bottling is done before the process of fermentation has ceased. When the pressure of the cork is removed, the carbon dioxide which has accumulated in the course of fermentation after the process of bottling is permitted to escape. The following statement of the strength of various wines is compiled from the table of Roscoe.

Port (old bottled) ..	20·2	per cent.
Port (newly bottled) ..	17·4	,,
Montilla sherry (1854) ..	16·3	,,
Fine marsala	17·0	,,
Madeira	16·1	,,
Beaune	13·5	,,
Various hocks ..	9·4 to 8·7	,,
Bordeaux	6·4 to 8·7	,,

These estimates, of course, do not begin to account for the differences in flavour displayed by various wines. These are due in the main to the presence of chemical bodies of great variety which are known as esters or compound esters, and which we must discuss later. These are very volatile fluids, which, in the majority of cases, have an agreeable odour. They are mainly formed by the action of acids upon alcohol.

Other Constituents of Wine. We have to recognise the acids of wines, therefore, as very important. These may be at least seven in number, most of them being organic acids. They occur largely in combination with various metals, such as potassium, sodium, calcium, magnesium, and iron. The free acidity of wines, reckoned as tartaric acid, varies from 0·2 per cent. in the best wines to as much as 0·7 per cent. in inferior wines. More than 1 per cent. of free acid makes the wine practically undrinkable. The proportion of acidity in a large number of good wines of various kinds, as stated in a well-known German table, varies within only very small limits.

There are so-called wines which are not wines at all; there is no real trace of the vine in them. Other wines are only in part derived from the grape. Many wines have alcohol added to them from without, and many more have esters artificially added to them in order to produce cheap imitations of other wines. Many wines, especially French, Spanish, and Italian, are plastered—that is to say, have calcium sulphate added to them. The consequence is the production of tartrate of calcium, which is precipitated. In such wines the acidity is represented only by an acid called *malic acid* and not by tartaric acid at all.

A complete analysis of wines shows that their nutritive value is practically nil, except for the sugar contained in sweet wines. There is, of course, no reasonable proportion whatever between such nutritive value of wines and their cost.

The distillation of wines produces brandy. This contains a large number of esters, and from 35 to 45 per cent. of ethyl alcohol.

Spirits. Besides brandy, made from the grape, we have to consider rum made from molasses, which is the residue that cannot be crystallised after as much cane sugar as possible has been crystallised from the juice of the sugar cane. The molasses are dissolved in water, yeast is added, and, after fermentation, the product is distilled. The characteristic ester of rum is called *butylic ester*, and this spirit contains from 50 to 70 per cent. of ethyl alcohol. Whisky is obtained by distillation of beer, and in a considerable variety of other ways. It contains from 50 to 60 per cent. of ethyl alcohol. The raw product contains a number of highly objectionable and poisonous substances, especially fusel oil and furfurol. Besides those we have mentioned we may note various other spirits—absolute alcohol, which contains nothing but alcohol except for about ½ per cent. of water; rectified spirit, which is 90 per cent. absolute alcohol; proof spirit, which contains 49·3 per cent. by weight of pure alcohol and 57·09 per cent. by volume. For Excise purposes the strength of alcohol in solutions is always estimated and stated by comparison with proof spirit. "Twenty-five over proof" describes a spirit which is such that 100 volumes of it diluted with twenty-five volumes of water will be equivalent to proof spirit. "Twenty-five under proof" means that 100 volumes of the spirit so described contain seventy-five of proof spirit. Next comes geneva or hollands, which contains from 50 to 60 per cent. of alcohol, and is flavoured with oil of juniper. On this ground it is supposed by ignorant persons to be of value in disease of the kidneys, but, as a matter of fact, both the alcohol and juniper are deleterious.

German Spirit. Many other spirits can be obtained from vegetable sources; arrack, for instance, is obtained from coconut or palm juice, and Japanese spirit from rice. Much more important, however, is German spirit, which is obtained from the potato, in consequence of the following facts. Any kind of starch, when boiled with dilute acids, is changed into sugars. The acid acts as a catalyst, since it is not itself changed. The addition of lime to the mixture separates the sulphuric acid by the precipitation of the insoluble sulphate of lime, and the sugar is left in solution. It can then be used for the manufacture of alcohol. In thoroughly characteristic fashion the Germans have discovered, first of all, how to manure unpromising soil so that it shall yield abundant potatoes; secondly, how to obtain sugar and then alcohol from these; and thirdly, how to obtain a market for the potato spirit which results. It was lately estimated that we pay the Germans £1,600,000 per annum for such spirit. There is, of course, no reason in the world but our carelessness of science to prevent us from producing any quantity of this valuable spirit at home—valuable, that is, for many uses outside the body.

Beer. The chief source of beer is barley. When the barley grain is moistened with water and exposed to the atmosphere, it begins to germinate, while its starch is largely converted

into grape sugar, as we have already seen. The reader will write tor himself the equation representing this change. A constant temperature has to be maintained, and the consequence is that all the starch originally present in the grain appears in solution as grape sugar. The temperature is then suddenly raised, and the young shoots of barley are killed. The grain in this state is known as malt. Malt is used to obtain sugar, by means of the enzyme diastase, from the starch present in untreated grain, which sugar, maltose, is then fermented with yeast, yielding beer.

Beer conspicuously differs from wine and other alcoholic liquors in having a small nutritive value. This has been very much overrated in the past, and, in any case, the proportion of its nutritive value to its cost is ridiculously low. The proportion of alcohol in various beers varies. Burton ale contains nearly 6 per cent., and Edinburgh ale the same amount. London porter varies a good deal from about 5·4 to 6·9 per cent. Some lager beer, despite the general opinion that it contains very much less alcohol, contains 5·1 per cent. There are various German beers, however, which contain as little as 2 per cent. The German beers contain a comparatively small quantity of the chemical bodies which are grouped as *extractives*, and this is an advantage, since these bodies are difficult of digestion. The other important constituents of beer are, on the average, as follows: Water, 90 per cent.; various organic acids, 0·1 to 0·3 per cent.; sugars, 4½ to 5½ per cent. Quite an appreciable quantity of albumen also occurs in beer, but what nutritive value it has depends mainly upon its sugar.

The hops used in brewing are mainly valued for their flavour. Their only bearing on the chemistry of the subject is that they tend to check the further fermentation called *acetous*.

Other Alcoholic Liquors. There are many liqueurs which are compounded from alcohol and aromatic essences. Some are sweet, and others, such as vermouth, are bitter. There are two alcoholic products obtained from animal sources—the ancient *mead*, which is obtained by the fermentation of honey, and the well-known product *koumiss*, which is obtained by the fermentation of mare's milk, and which may be tolerated by the stomach of an invalid when more modern dietetic methods are not at hand. The alcoholic fermentation of apples yields cider, which contains a good deal of sugar, and, as a rule, by no means so little alcohol as is usually thought. In general, a cider is quite as strong as a beer.

Alcohol in Drugs. Alcohol is also contained in a very large number of drugs—notably in tinctures, essences, and so on. It has lately been demonstrated that, especially in the United States of America, alcohol is one of the most important ingredients of patent medicines. Certain types of blackguards have discovered that they may line their pockets by increasing the facilities with which women especially may become drunkards. It has been shown that many so-called patent medicines may consist of as much as 45 per cent. of alcohol with a little flavouring matter and nothing else. This is a form of criminal fraud which must surely attract the attention of the law before long. It has played its part in producing that lamentable increase of alcoholism among women, upon which all observers are agreed, and which, if we remember the extreme importance of women in relation to the future, must be recognised as one of the gravest menaces to the continuance of our civilisation.

Characters of Alcohol. Pure waterless or anhydrous alcohol is an inflammable fluid having a specific gravity of 0·803. It has a great affinity for water, and the result of this is that it is almost impossible to obtain it without this impurity, and that alcohol is one of the most powerful dehydrating substances known. In order to remove water from it, as far as possible, many devices have been adopted. The so-called absolute alcohol of commerce, which, as we have seen, is not really absolute, is obtained by the use of caustic lime or calcium oxide, CaO. Small pieces of caustic lime are placed in spirits of wine in a retort, and after a few hours the alcohol can be distilled off, the lime having been slaked or converted into calcium hydrate. Absolute alcohol is very mobile and refractive. It has scarcely any appreciable taste or smell, though, of course, it stimulates the nerves of common sensation in the mouth, and so, by an abuse of language, it is described as having a burning taste. This so-called taste is really due mainly, if not entirely, to the rapid abstraction of water from the tissues with which the alcohol comes into contact. Alcohol does not conduct electricity. At a temperature of about 100° C. below zero is becomes viscous. It freezes only when it reachet a temperature of 130° C. below zero. The fluidity of this substance at low temperatures, and its high coefficient of expansion [see PHYSICS], make it very valuable for use in thermometers.

Alcohol and Water. The affinity of alcohol for water is so great that we begin to suspect that some chemical action must be involved. This suspicion becomes practically a certainty when we discover that the dilution of alcohol with water causes the evolution of much heat, and also that up to a certain point the mixture of water and alcohol causes a reduction of the volume occupied by the two. No doubt there is some chemical action involved, and the satisfaction, or transformation of chemical potential energy, is expressed by the appearance of that form of kinetic energy which we call *heat*—just as the burning of coal produces heat. Sulphuric acid and water behave similarly.

These and many other instances make it plain that, as usual, we find some reservation necessary when we come to look more closely into the question of the dogmatic distinction between compounds and mixtures. The distinction is a real one, but Nature is continuous, and, as everywhere else, we find, if we look carefully enough, gradations between all her various processes.

C. W. SALEEBY

THE EBBING FORTUNES OF A STUART KING

JAMES II. RECEIVES NEWS OF THE LANDING OF WILLIAM OF ORANGE

THE ENGLISH AND DUTCH NAVIES DEFEAT THAT OF LOUIS XIV., ALLY OF JAMES II., OFF LA HOGUE.

The Ambition of the "Grand Monarch," and the Unexpected Changes It Brought Throughout Europe.

RISE & DECLINE OF THE BOURBONS

The age of Louis XIV., which forms the first sub-section of our next period, coincides with a marked period of our own history. The personal rule of Louis began immediately before the restoration of Charles II.; it ended immediately after the accession of the Elector of Hanover. The "glorious Revolution" divides it into two almost exactly equal halves, during the first of which, consciously or unconsciously, the English Government habitually played into the hands of the Grand Monarque, whereas during the second William III. and Marlborough were the protagonists in resistance to his aggression.

English Kings in French Pay. Charles II. and James II. were the French king's first enemies; both—the one secretly and the other openly—were adherents of Catholicism; and aggressive Catholicism, though with an element of antagonism to the papacy, was a part of Louis' programme, and the Stuarts were quite willing to purchase freedom from parliamentary control at the price of subservience to France. In England, people and Parliament were in ignorance of these fundamental facts; the French alliance and wars with the Dutch were both features of the Commonwealth policy, which in foreign affairs was popular. Consequently, people and Parliament acquiesced in an apparent continuity which was an actual reversal.

The Revocation of the Edict of Nantes revealed the designs of the French king; the English Revolution necessitated the association of English and Dutch, while the exiled king relied on French protection and support. England, it is true, was not enthusiastic in support of William III.'s wars against Louis, but apathy was converted into fury when Louis recognised the son of James II. as king of England, and the country flung itself into the War of the Spanish Succession with ardour, though its direct interest in the actual issue was small.

Complete Union with Scotland. The fruits of victory which fell to Great Britain at the end seemed inadequate, but she had suffered infinitely less than any of the other belligerents; and ever since La Hogue, in 1692, her naval pre-eminence had been becoming more and more decisively established. Incidentally, also, the threat of complete separation from Scotland in the middle of a great war had forced England to assent instead to an all but complete union. The two countries ceased to be internationally distinct, and were merged in Great Britain—a fact of vital importance in the next stage of international rivalries.

Although Catholic aggression, or suppression of Protestantism, was part of the plans of Louis, this was not distinctively the case during the first half of his reign; nor was there even in the latter period any pretence that Louis was at the head of the Catholic States of Europe. On the contrary, the papacy was in direct opposition. The primary objects which the French king had in view were the magnification of the monarchy in France and the magnification of France in Europe. For the second purpose, the great end to be attained was the annexation to France of roughly the whole of the old heritage of Burgundy, of which a great part was still attached to Spain. He had this end in view when he married the eldest Spanish princess, whose half-brother shortly after succeeded to the Spanish throne, while her half-sister was married to the Emperor Leopold, the head of the German Hapsburgs.

The Treason of Charles II. The accession of Charles II. in Spain permitted Louis to claim the Burgundian provinces for his wife, on the basis of a law which gave the female children of a first marriage priority over even the male children of a second marriage. These claims Louis in part made good by the campaigns of 1667–8. He could afford to pay little regard to the formation of the triple alliance of England, Holland, and Sweden, which was the outcome of the alarm caused by his aggression, since he knew that the King of England was clever enough to circumvent his Ministers for a substantial consideration, and that Sweden also might be diplomatically detached. Holland itself was the next object of his aggression, with the additional motive that the Dutch Republic stood in the way of the development of his plans for suppressing the Huguenot religion in France.

England and Holland Drawn Together. The attack was opened in association with England, during a convenient prorogation of Parliament, in 1672. Holland, however, resisted with her traditional resolution. The fall of the Republican Government and the restoration of the House of Orange in the person of young William III. to the office of Stadtholder provided a leader of unsurpassed tenacity and shrewdness, and completely changed the relations of Holland and England, William being the nephew of Charles. England withdrew, and at the same time the powers took alarm, Catholic as well as Protestant. Louis found himself facing the prospect of a European combination. Turenne conducted a series of campaigns of extraordinary brilliancy, but his career was ended in 1675 by a stray bullet.

Next year the extraordinary development of the French navy by Colbert was demonstrated. Conscious of the strain on his resources, however, Louis was ready for a peace on favourable terms, which were obtained at the Treaty of Nimeguen

in 1678. But Nimeguen did not satisfy Louis The audacity with which he proceeded to interpret treaties in his own favour could hardly be tolerated by the Hapsburgs, German or Spanish; and the diplomacy which had held Protestant states neutral in the late wars was nullified in 1685 by the Revocation of the Edict of Nantes, which also drove a large part of the best of the French industrial population into exile in England, Holland, and Germany.

The Grand Monarch's Futile Exertions. The Pope himself condemned the Revocation, and Louis was consciously and confidently preparing a single-handed attack on the European combination, which was on the verge of completion when the revolution in England decisively united the naval Powers. For this Louis had himself to blame, since he made his first move by invading the Palatinate, thereby leaving the ruler of Holland free to go to assist in the expulsion of King James from England. By the time that Louis was in a position to turn upon Holland, the English crown was firmly set on the head of the Dutch Stadtholder, and the great navy which had inflicted a disastrous defeat on the English fleet off Beachy Head was shattered at the battle of La Hogue in 1692. The allies, however, were sufficiently diverse in their aims to enable Louis, after just holding his own, to negotiate terms with them separately, which were embodied in the Treaty of Ryswick in 1697.

The Spanish Succession. Louis was still further from having achieved his ends than he had been after Nimeguen. But fresh opportunities were presented by the now acute question of the Spanish succession. The Spanish king was dying without issue; the children of his two sisters were also the children of Louis and of the Emperor Leopold respectively. The acquisition of the whole Spanish dominion by either Power was manifestly destructive to the balance, while there had been formal renunciations on the part of both the princesses. A partition was the obvious course.

The Alliance Against Louis. An agreement between the interested parties had bestowed the main inheritance on a grandson of the emperor, the electoral Prince of Bavaria, who was outside the Austrian succession itself, but in 1699 the prince died. King Charles of Spain followed suit, after naming Philip, a grandson of Louis, as his heir, though the Powers had agreed upon a fresh partition. Louis repudiated the partition and accepted the will; Austria prepared to assert her own claims; the action of Holland would be largely dependant on England, and the action of England was decided by Louis' recognition of James Edward Stuart as king of England, at the deathbed of James II.

LOUIS XIV. OF FRANCE RECEIVING THE ELECTOR OF SAXONY

Once more, Europe was in alliance to check the unbridled and insatiable aggrandisement of Louis.

Marlborough's Brilliant Strategy. Louis sought to bring the allies to their knees by striking straight at Vienna, but the attempt was completely wrecked by Marlborough's brilliant strategy, which united his own forces with those of Prince Eugène and shattered the French and the Bavarians, whose prince had joined Louis, at Blenheim. Year by year, in a series of skilful campaigns, the French king's conquests in the Spanish Netherlands were wrested from him, but a turn in domestic politics placed the Tory peace party in power in England.

The Hapsburgs and Bourbons Divide. Twice in the course of the war Louis had been ready to make peace on terms which would have fully satisfied even William of Orange, had he been alive. But those terms had been rejected, and now the practical defection of England secured him very much more favourable conditions, under the Treaty of Utrecht in

FAMOUS VICTORIES OF MARLBOROUGH

THE SCOTS GREYS STORMING THE VILLAGE AT THE BATTLE OF BLENHEIM

THE DUKE OF MARLBOROUGH AT THE BATTLE OF MALPLAQUET

1713. The Spanish Netherlands were transferred to Austria, but a Bourbon sat on the Spanish as well as on the French throne, and Italy was roughly divided between Hapsburgs and Bourbons. To Britain the most material gain was that Louis was unable to intervene on behalf of the Stuarts when Queen Anne died and a coup d'état secured the Hanoverian succession.

In spite of the disaster of the War of the Spanish Succession, Louis left France with her borders greatly extended, her frontier strengthened, and dynastically in close association with Spain, which was now definitely severed from the Hapsburg connection. Moreover, the power of the crown was practically unchecked. On the other hand, the tremendous series of wars had exhausted the resources of France, and her industrial population had been depleted by the Revocation of the Edict of Nantes. The middle class was excluded from all share in the government; the peasantry, crushed by taxation, were at the mercy of the lords of the soil, and the lords of the soil themselves were undergoing a process of rapid degeneration, which was hastened under the regency which followed the death of the old king, whose heir was a sickly child.

The Bourbon Dynasties Combine. The possibility that the King of Spain might after all claim the succession to the French throne, which he had renounced, threw the French Government into temporary alliance with the British Government for the maintenance in both countries of the succession as laid down in the Treaty of Utrecht. For a time the disturbing factor in Europe was to be found in the jealousies of Austria and Spain under her new dynasty, and in the ambitions of the Spanish queen-consort, the Italian Elizabeth Farnese, for the advancement of her own children, whose succession to the Spanish throne was blocked by the offspring of Philip's first wife. The prospect of a disputed French succession waned with the marriage of young Louis XV., and thus cleared the way for a "family compact" between the Bourbon dynasties for the aggrandisement of the Bourbons and the humiliation of the Hapsburgs and of Great Britain.

Signs of a Coming Storm. The compact, which was a secret one, made in 1733, did not precipitate war, for the French minister, Fleury, was quite aware that much recuperation was necessary for France before she could plunge into a great war with Spain for her ally. The English minister, Walpole, was equally anxious to avoid the arbitrament of arms, though he had information of the hostile designs. Both sides meant to achieve their respective ends by diplomatic methods. But the control was taken out of the hands of Fleury and Walpole by events which proved too strong for them. Commercial friction in the Spanish-American seas was exasperating popular feeling in both Spain and England, while the approach of a question of succession was exposing Austria to attack at the hands of any power which saw a prospect of profiting by her dismemberment.

THE FLIGHT OF THE FRENCH PROTESTANTS AFTER THE REVOCATION OF THE EDICT OF NANTES

Charles VI., emperor and head of the Hapsburgs, ruled over a group of states which did not recognise a single common law of succession; in some cases the title of his daughter Maria Theresa was good, in others it was at best doubtful. Charles obtained from most of the Powers a guarantee of the Pragmatic Sanction, or decree declaring Maria Theresa heir to the whole, but such promises usually provide loop-holes of escape which a diplomatic conscience finds quite large enough. Thus, in 1739, Walpole's hand was forced by a nation infuriated by tales of the high-handed doings of the

Spaniards, and war was declared between Spain and Great Britain. Immediately afterwards Charles VI. died; the Bavarian Elector put forward claims against Maria Theresa; Frederic of Prussia started a general conflagration by occupying Silesia with an army. Every Power found itself with something at stake, or hoped to snatch something out of the turmoil, and all Western Europe was very soon involved in the War of the Austrian Succession, however remote from its national interests.

The Sudden Rise of Prussia. The factor on which the world had notr eckoned was Prussia. In the past, the Elector of Brandenburg had stood on a par with other princes of the empire. In the Thirty Years' War, Brandenburg had done its best to remain neutral, and had never assumed anything approaching a leading position. In the second half of the century, however, the "Great Elector"—an astute politician and skilful soldier—had played his part with a consistent determination to strengthen the Electorate, making and breaking alliances, fighting or refusing to fight, with most advantageous results to himself, and little regard for moral considerations. His successor did little beyond achieving the status of King of Prussia, but Frederic William, who followed him, devoted himself to the organisation of his state and its army in a fashion which excited some derision, which derision his son, Frederic II., the Great, promptly showed on his accession, in 1740, to have been very much misplaced.

The Disturbed Balance of Power. The War of the Austrian Succession, which ended with the Peace of Aix-la-Chapelle in 1748, established the position of Prussia as a first-class power, while it confirmed the descent of Spain into the second class. Holland and Sweden had almost ceased to count. It left Maria Theresa in undisputed possession of her Hapsburg heritage, except for the cession of Silesia to Frederic. It also left her husband, Francis of Lorraine, emperor; in effect, the Hapsburgs were, relatively to the Bourbons, stronger at the end than at the beginning. Great Britain had lost nothing and gained nothing except, incidentally, freedom from the alarm of Jacobitism, which had been finally broken on the field of Culloden. But the rise of Prussia had decisively changed the whole favourite diplomatic problem of the balance of power; an Austrian domination of Central Europe was less to be feared than the activities of the Prussian king, who had, moreover, succeeded in making himself personally obnoxious to Maria Theresa, to the Russian Tsarina, and to the French king's mistress, Mme. de Pompadour.

FREDERICK THE GREAT RECEIVING THE HOMAGE OF HIS SUBJECTS
From the painting by Adolph Menzel

In the next European war, the rivalry of Bourbons and Hapsburgs, which had been an unfailing factor in every combination for a century and a half, disappeared altogether. Before the Seven Years' War broke out, in 1756, the one definite certainty was that France and Great Britain would fight, and that Austria and Prussia would fight. How the antagonists

would pair off was uncertain till the last moment. That war, in fact, resolved itself into a desperate struggle for life on the part of Prussia against a circle of foes, and a struggle for transoceanic empire between France and Great Britain.

France Swept from the Seas. It was almost an accident that Great Britain and Prussia were ranged on the same side. Some British and Hanoverian troops and large British subsidies enabled Frederic to hold his own in a contest numerically most unequal on land, and left Great Britain free to devote the whole of her real energies to the naval and colonial struggle, in which she was completely triumphant. France, wholly misapprehending the conditions, wasted blood and treasure on the Rhine and the Weser, while her fleet was wiped off the seas, and her effective foothold in America and India was finally cut away.

Problems of Overseas Expansion. For a century and a half England had been developing colonies along the seaboard of North America from Florida to Acadia. For a somewhat shorter period France had been developing colonies on the north and on the south of the British. British expansion would necessarily work westwards; French expansion would necessarily work south from Canada and north from Louisiana, blocking British expansion altogether. No compromise was possible; the future manifestly lay with the power whose maritime supremacy should enable her best to maintain communications with her colonies. But, strange though it now seems, this view of the position seemed hidden from the eyes of French observers.

English Supremacy Beyond the Seas. Similarly, for a century and a half an English company had been developing trade with India, and for half the time a French company had been doing likewise. In India, as in America, a stage had been reached in which the virtual elimination of either English or French had become inevitable. In 1744 Dupleix had begun the attempt to eliminate the British. Checked by the Peace of Aix-la-Chapelle, the contest had taken a new character, the rival companies taking the field as supporters of rival native dynasties, while in America the rival colonists were in collision. In India, as in America, naval supremacy was the condition of success. The insular position of England had necessitated the continuous development of her fleets; the continental position of France had absorbed her mainly in the development of armies. Colbert alone of French statesmen had turned his eyes to the ocean rather than to the Rhine. Hence, when the struggle came, it was France that was eliminated. In India the British were left without European rivals to complicate their relations with native powers; in North America they held the field though the outcome of the victory was to be a cleavage of the race.

The security of Prussia and the expansion of Britain were established by the Treaties of Paris and Hubertsburg in 1763. Spain had gained nothing by a belated intervention when the war was drawing to a close. After the peace, the German sovereigns were engaged mainly on the organisation of their own States; their foreign policy was concerned with the East rather than the West, with Russia, Poland, and Turkey, rather than with France and Great Britain. The western Powers looked on at the partition of Poland between Austria, Prussia, and Russia in 1772.

Great Britain's Loss of Her Colonies. Great Britain embroiled herself in a dispute with her American colonies, upon whom she made demands which were in themselves justifiable both technically and morally, in a manner which was peculiarly irritating, and which set at naught more than one of the fundamental doctrines on which the Constitution rested. The result was first acute friction, then unsuccessful attempts at coercion, then point-blank defiance and open hostilities. The colonies, which had hitherto studiously professed loyalty, soon changed their attitude and fought avowedly for complete independence.

Concentration Against Great Britain. France found the opportunity of revenge for which she had been waiting fifteen years. She had awakened to the fact that the disasters of the Seven Years' War were due to the maritime superiority of the British; she had been resolutely reconstructing her navy, and her intervention on behalf of the colonies showed that Great Britain was no longer the irresistible mistress of the seas. But although the old family compact reappeared, and Spain joined in, and the French fleets secured the American victory, the effect was to concentrate British energies on the renewed struggle with the Bourbons; the tottering naval supremacy of the islanders asserted itself once more. The Peace of Versailles, which closed the war in 1783, left Britain shorn of half her empire, but it had passed not to the Bourbons, but to an independent nation of British race, and Britain was still the Queen of the Seas.

England Established in India, and Monarchy loses France. Meanwhile, the territorial dominion which Clive had won in Bengal while the Seven Years' War was raging was confirmed by the able administration of Warren Hastings. Great Britain had become definitely one of the powers in India, and it was soon to become evident that she must either cease to be so altogether or compel her position to be recognised as paramount. But in France the cataclysm was approaching. The system of government was rotten. To the world, France displayed a brilliant and extravagant court and a noblesse incomparably the most polished in the world. Below there was a populace savage with oppression, gaunt with starvation. The stage had been passed when the situation might have been saved by level-headed moderation and relief of the ghastly burden of taxation. The flood-gates were opened; the deluge swept over France, whirling down the crown and the noblesse; and the Republic emerged.

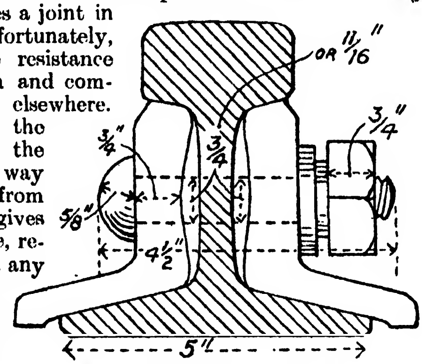
ARTHUR D. INNES

Railway Joints, Crossings, and Points. Friction on the Rails. Water Supply. Culverts, Fencing, and Platform Structures.

TRACK EQUIPMENT

Rail Joints. The simple expression *rail joints* comprises what has always been, and still is, one of the main difficulties of making a satisfactory railway. The forms of joint are innumerable; none is perfect. A common form is shown in section in 51.

To understand the requisites for a good rail joint it is necessary to have a clear idea of the mechanical action of the loaded wheel passing along the rail. The rail is bent concave upwards between the sleepers between which the wheel is at the moment, and concave downwards both in front and behind, but particularly in front. The action will be better understood in detail by the light of the theorem of three moments. Thus, as an engine moves over the line it is accompanied by a wave in the rails which subjects the upper and lower flanges alternately to tension and compression. When this wave reaches a joint in the rails, it reaches, unfortunately, a place at which the resistance offered both to tension and com-[...]on is less than elsewhere. Consequently the rail, the immediate support of the wheel and flange, gives way unduly at this spot, and from the very fact that it gives way, this spot of course, receives heavier jolts than any other part. There is a popular belief that the shock which is often distinguished in a railway carriage as the wheels pass over a joint, is due to the gap provided for the expansion of the rail on a rise in temperature. This, however, is not the case. Similar gaps filed in the head of the rail away from the joint cause no appreciable shock as the engine passes. The jolt at the joint is due to the weakness inherent in the joint, and until the perfect joint is discovered the jolt is inevitable.



51. COMMON FORM OF RAIL JOINT

The *stiffness* and *moment of resistance* of a rail at the joint should be the same as elsewhere. This condition has been the aim of all designers of rail joints, and it must be the object of all whose business it is to see that rail joints are made and maintained that these conditions are as nearly perfect as circumstances permit.

Provision for Joints. The joint is supported by placing the sleepers on each side of it closer together than the others. In light railways the joint may be placed on the top of a sleeper. This method cannot be used on heavier lines, as the weakness of the joint causes pressure at this point to be less distributed than elsewhere, and the sleeper over which the joint is placed is soon knocked out of level.

The plan of making the rails *break joint*—that is to say, placing the joint of one rail half-way between joints of the other—is sometimes practised.

Care must be taken that the proper odd lengths of rail are used in curves, as otherwise the sleepers will come to be unevenly distributed, producing an ununiform road-bed. Thus, if there be a sleeper at each joint and five between, the effect of the joints in the inner rail being displaced forwards on rounding a curve is to bring the sleepers under the first part of the next rail nearer together, and this defect continues after the curve is passed and until corrected. The advantage of making the rails to break joint is the increased resistance which is thereby given to any lateral displacement of the line.

In general, the joint sleepers in the case of a suspended joint should be a distance apart equal to six-tenths of the distance apart of the intermediate sleepers. A *suspended* joint is a joint placed between two sleepers, which are called *joint sleepers*. The advantage of longitudinal sleepers in facilitating the design of a good rail joint will now be understood.

Testing of Rails. Rails are [...] of two tested at the works where they [...] the frogs [...] those responsible for the quality will at [...]alities used for the railway stipul[...] also cont[...] of manufor overlooking the whol[...] facture. Both chemi[...] It wi[...]chanical tests are required to est[...] from A [...]ue of a steel rail. The suitability of at the [...] chiefly depends upon the quantity [...]ever the [...] various metalloids—carbon, [...]n of the [...]ilicon, and sulphur. The effect them, and [...]stances upon the properties of [...] studied in another section. For [...] purpose it is sufficient to say that [...] should be absent, phosphorus should not exceed ·1 per cent., silicon should not exceed ·2 per cent., carbon should exist in quantities between ·33 and ·45 per cent., a rather larger portion being allowed for heavy rails, but [no]t more than ·55 per cent. in any case.

A high proportion of carbon renders the rail very much harder, and therefore more resistant

to wear, but at the same time it renders it brittle, so that a high proportion of carbon is suitable only for strong, well-built roads, over which a great deal of heavy traffic passes without much shock. From this it will be seen that a high carbon steel is not suitable for new construction at all, since, however carefully built, a recent construction is always liable to irregular settlement, and new roads seldom have very much traffic to deal with at first. The presence of nickel adds to the durability of a rail, and nickel steel rails have been used for this reason on curves over which a heavy traffic passes, but the advantage here conferred has to be carefully balanced against the extra cost of introducing the nickel. The inspector for the railway is usually furnished by the manufacturer with an analysis of the steel made each day from drillings taken from a test ingot.

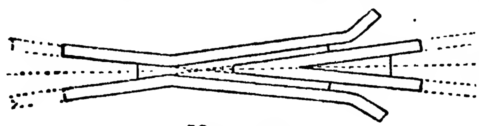
Mechanical Tests. The mechanical tests include the ordinary determinations of elastic limit, ultimate strength and elongation at rupture, but in default of these or in addition to them it is very common to resort to the drop test. Where rails are not specially rolled for the construction of the road, the drop test furnishes a ready means of ascertaining the quality of the metal of which they are composed.

The Drop Test. For the drop test the rail is placed on solid supports 3 ft. apart, and a ton weight is allowed to drop upon the rail midway between the supports. The total length of the rail should not exceed 6 ft., or the weight of the overhanging portions will add to the resistance of the central part. For rails of 50 lb. weight to the yard the drop should be 14 ft., and 1 ft. may be added for each increase of 5 lb. in the weight of the rail per yard.

The rails should correspond accurately to the prescribed weight. Variations in section should not exceed $\frac{1}{32}$ in.; variation in length should not exceed $\frac{1}{4}$ in. The holes for the bolts at the joints must be accurately placed, and must be clean—that is, free from burrs.

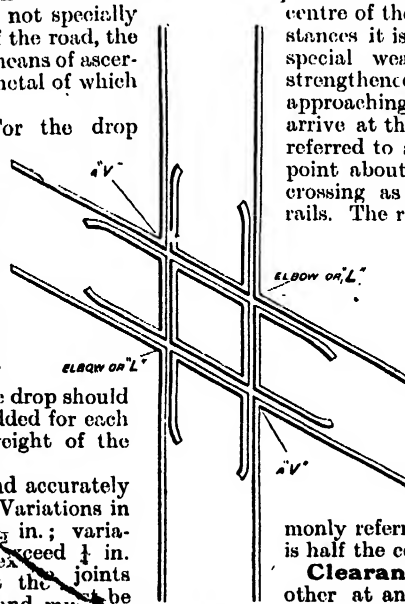
Rails must show no irregularity on top, but be perfectly smooth; the ends must be cut precisely at right angles and all burr removed. It is convenient that the name of the manufacturer be rolled in raised letters on the side of the web of the rail, together with the date, and it is sometimes provided that the number of the "blow" shall be stamped also, so that if a number of rails from one blow prove defective, the remainder may be identified. The *heat treatment* of steel should be studied in the article on metallurgy, as the future useful service of the rail greatly depends upon it. Rails being *the* essential things about a railway, it is impossible to know too much about them.

Points and Crossings. The advantage of constructing the tyres of the wheels of rolling-stock with flanges in order to guide them along the rails is accompanied by the drawback that, whenever it is desired to transfer rolling-stock from one set of rails to another, the continuity of the latter must be broken. Gaps set in the rails to permit the passage of wheel flanges are called *crossings*.



52. A FROG

The Frog. A diagram is given [52] of the gaps provided at the place where two lines of way first come into contact; it is often referred to as a *frog*. The point in the middle where the dotted lines are seen to cross each other is the centre of the crossing. It will be seen that the two rails approaching each other from the left meet in a point which is not extended to the centre of the crossing, but rounded off before this is reached. There is danger lest the flanges of wheels passing from right to left should strike this point if it be advanced too close to the centre of the crossing. Under any circumstances it is a place that is subjected to special wear, and must be fixed and strengthened with special care. The rails approaching each other from the right arrive at their minimum distance apart—referred to as the *throat* of the frog—at a point about as far from the centre of the crossing as the termination of the other rails. The rails then increase their distance apart, and pass on each side of the opposing rails, forming a guide for the outer side of the flanges of the wheels of the rolling stock, and are finally splayed out to avoid any danger of being struck by the flanges of wheels coming from the other direction.

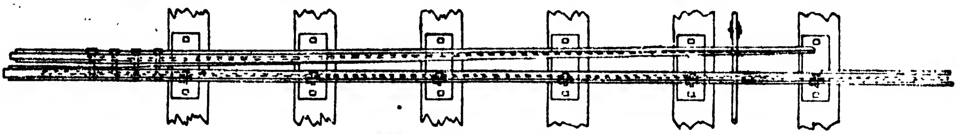


53. LARGE ANGLE CROSSING

The Angle. The inclination of the two sets of rails to each other is the *angle of the crossing;* it is commonly referred to by number; the number is half the cotangent of half the angle.

Clearance. Lines may cross each other at any angle. In order to understand the provisions which should be made to enable this to be done with safety, it must be remembered that the flanges are upon the inner sides of the wheels and project about an inch beneath the level of the top of the rails, also that the distance between the side of the flange in contact with one rail and the side of the flange in contact with the other rail is rather less than the gauge of the railway—that is to say, there is some play or *clearance* between the rails and the wheel flanges. When two lines of railway cross at a large angle, as is

shown diagrammatically in 53, a jolt as the wheel passes over the gap cannot be avoided. When, however, as in 52, the crossing is made at a small angle, the jolt is very greatly diminished, if not entirely obviated. The effect of the acuteness of the angle of crossing is to bring the gaps in the rails into the form of an elongated parallelogram; and since the breadth of the tyres of the wheels is always made greater than that of the top of the rails, the wheel will have already reached the new rail before it has entirely left the old.



54. RAILWAY POINT

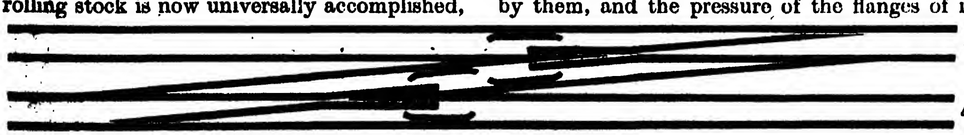
Guide Rails. It will be seen in 53 that additional rails are provided inside the usual rails to guide the wheels by confining the movements of the flanges on their outer sides. This has already been referred to in 52. The effect of these is to provide that at the moment when one wheel is passing a gap, and therefore not so completely under the guidance of its flange as at other times, the other wheel fixed to the same axle is provided with a rail on each side of its flange, so that any tendency to movement from side to side is sufficiently opposed.

Switches and Points. One means of diverting a train from the track upon which it is running to another line of way has been sufficiently described in the account which has been given of the contractor's or temporary railway. These contractor's crossing and *stub* switches have been constructed with elaboration for permanent use, but have not been found satisfactory. On the permanent way the diversion of rolling stock is now universally accomplished, in the first instance, by means of a switch and completed by an *elbow* or "L," a [illegible] the rail, of which an example will be seen [illegible] centre of 53. The *points* or *switches* a[illegible] given to pointed rails that can be switched aside so as to be passed by the wheel flanges either on one side or the other, according to the position of the points. An illustration of a point, together with the *stock* rail or ordinary rail with which it is associated, is given in 54. The points are well illustrated in the photograph [55]. The length of the switch, often called *tongue* rail, is usually about 15 ft. At the thick end it is pivoted, and here its cross-section is the same as that of the stock rail; its distance from the stock rail at this end must be sufficient to allow the flanges of the wheels of the rolling stock to pass between. At the other end it is pointed, and the movement of the pivot is to enable this end to be moved, either away from the stock rail so that the flanges of the wheels can pass at this end also, or close against it, so that the point comes between the wheel flange and the stock rail, thus diverting the wheel and causing it to roll upon the switch.

55. SECTION OF RAILWAY LINE SHOWING POINTS

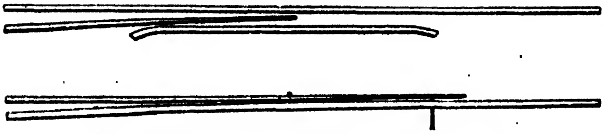
Cross-over Road. Fig. 56 shows diagrammatically the very ordinary arrangement provided for crossing from one to another of two parallel roads. The position of the frogs and switches and the guide rails will at once be recognised. The photo [55] also contains several illustrations.

Trailing Points. It will be seen [56] that trains passing from A to B come upon the point rails at the *heel* or pivot end first. Thus, whatever the position of the points, the direction of the train could not be affected by them, and the pressure of the flanges of its wheels would tend to press the point rails into their right position and retain them there.

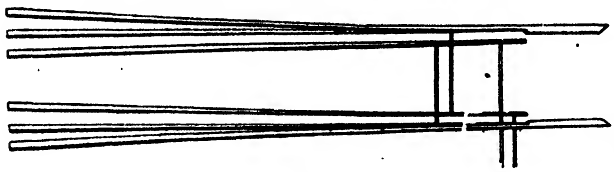


56. ORDINARY CROSS-OVER ARRANGEMENT OF RAILS

Facing Points. On the other hand, trains passing from B to A would come upon the

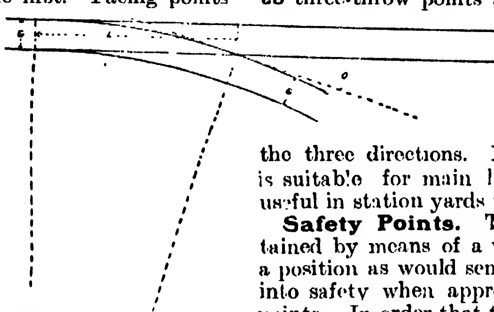


57. THE MOST SIMPLE SYSTEM OF POINTS



58. THREE-THROW POINTS

point rails, point first. Thus, if these were not in the right position the train would go wrong, and if, while the train were passing, the points were changed in position the train would be broken in two, by the latter part of it being differently directed to the first. Facing points are, therefore, very much more dangerous than trailing points, and should be avoided wherever possible. Thus, if 56 be taken to represent a double line of way, the direction of traffic would be from A to B and from D to C, and not the other way about under any avoidable circumstances.



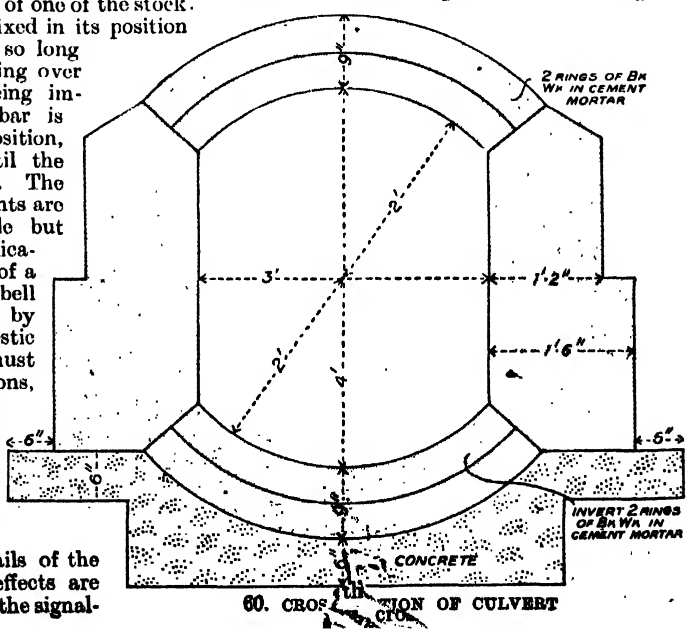
59. TURN-OUT FROM MAIN LINE

Locking-bar. In places where facing points cannot be avoided, the mechanism by which the points are shifted is best connected with a bar called a locking-bar, disposed on the inner side of one of the stock-rails so as to be locked or fixed in its position by the flanges of the wheels so long as a train is passing or standing over the points. The points, being immovable while the locking-bar is fixed, are kept in one position, whether right or wrong, until the whole train has moved by. The mechanism by which the points are moved is simple in principle but exceedingly complex in application. It consists essentially of a series of links and elbows or bell cranks, such as are arranged by the bell-hanger about the domestic house. Since movements must be provided in both directions, rods must generally be used instead of wires, and the levers are usually connected with the signalling apparatus in such a way that the position of the points is known by the position of the signals.

Interlocking. The details of the mechanism by which these effects are produced and controlled from the signal-box are various and complicated, especially at crowded junctions, where there are often many acres of ground covered with crossing and branching lines of way. In these situations electric methods are now being introduced.

Varieties of Points. Points are not necessarily provided with more than one tongue. Thus, in 57 is shown diagrammatically what are still called points, though only one is, in fact, a movable point. It will be seen that the movement of this switch at the bottom of this figure will suffice to change the direction of a pair of wheels coming from the right, so that on reaching the fixed point at the top of the figure the flange of the wheel on that rail will already have been brought into the right position to pass it, whether on one side or the other. In 58 three-throw points are shown diagrammatically. Here more than one set of points are introduced at the same spot, and a train coming from the right may be sent in any one of the three directions. Neither of these devices is suitable for main line traffic, but is often useful in station yards where space is confined.

Safety Points. These are points maintained by means of a weight or spring is such a position as would send a train or engine, etc., into safety when approaching them as facing points. In order that the train or engine, etc., may be sent in the alternative direction, someone must lift the weight or release the spring. There are many situations where this device is useful; it is often provided for sidings lest



60. CROSS-SECTION OF CULVERT

the trucks therein be blown by wind or otherwise brought on to the main line by accident.

Design. Points and crossings are critical parts of the permanent way; they are subject to special wear, and must be specially designed and supported. The great majority of railway accidents are due directly or indirectly to defects in their parts. The approximation of the sleepers has already been shown in **43.** The actual dimensions of the metal contained in the frogs and switches depend upon the section of the rail in use, the gauge of the line, and other circumstances. A junction or crossing may have to be effected at very different angles.

One line may be straight and another curved, or both lines may be on the curve, and they may be curving in the same or in the opposite direction, introducing trigonometrical problems of some complexity.

A Turn-out. In **59** the simple case of a turn-out from the main lines is exhibited diagrammatically. Here G represents the gauge of the railway in feet, R the radius of the curve by which the turn-out is effected, and A the angle of the crossing; L, the distance in feet between the springing of the curve from the main lines and the centre of the crossing, is called the *lead*. The following relations are immediately obvious:

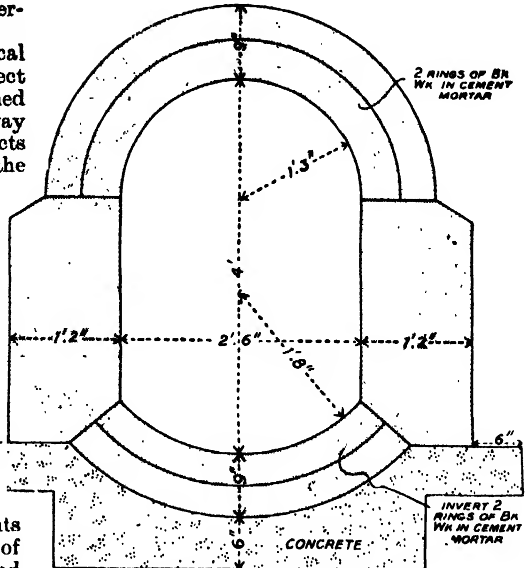
$$L = G \cot \frac{\theta}{2},$$

$$R = \frac{G}{1 - \cos \theta} - \frac{G}{2}.$$

The two rails of the line turning out of the other have, of course, radii of curvatures differing by G, the width of the gauge separating them. R is the radius of curvature of the centre line.

A convenient form for expressing the lead is $\sqrt{(R_1 + R_2)G}$, in which R_1 and R_2 are the radii of curvature of the two rails respectively.

In the foregoing, it is assumed that the points are placed at the springing of the curve and are themselves curved to the proper radius; also, that the lines of the frog are also curved. These conditions rarely obtain except in street railways when curves are sharp; consequently, in careful work the fact that these portions of the turn-out are straight lines must be taken into account. It is, perhaps, well to point out that considerations of space have caused the curves in **59** to be drawn very much sharper than they would be made upon the main lines of an ordinary passenger railway.



61. CROSS-SECTION OF CULVERT

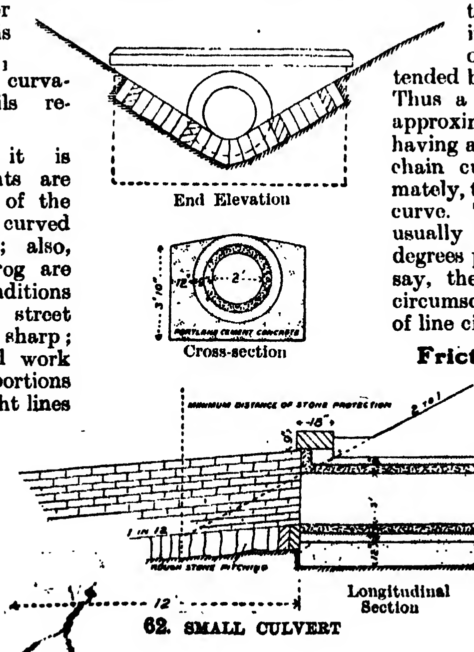
Weight of Rails. The proper weight of rails for a railway may be calculated from the following formula:

weight per yard (linear) $= 17\,(\mathrm{E} + \cdot 0001\,\mathrm{E}v^2)^{\frac{2}{3}}$,
where E is the maximum load on one wheel in tons and V is the maximum speed in miles per hour.

Thus, if the maximum load on one wheel were 10 tons and the maximum speed 40 miles per hour, the rails should weigh 87 lb. per yard, or about 75 tons per mile of single line.

Curves. The curves of a railway are described either according to the length of the radius of the circle of which they form part of the circumference, or according to the angle at the centre of the circle which is subtended by a chord 100 ft. in length. Thus a 6-degree curve would be, approximately, the same as a curve having a radius of 955 ft., and a 15-chain curve would be, approximately, the same as a 5 deg. 44 min. curve. The amount of curvature is usually referred to as so many degrees per mile of line—that is to say, the total number of degrees circumscribed divided by the length of line circumscribing them.

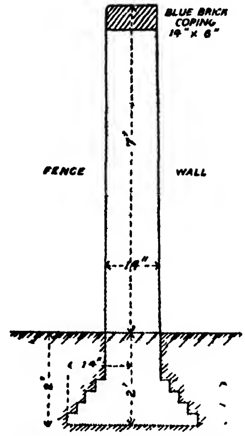
Friction on Curves. The extra wear and resistance to traction due to curvature is of course greater on a sharp curve than on a comparatively flat curve, but the length of the latter is proportionately greater, so that the aggregate effect of the curvature is governed by the magnitude of the sum of the central angles



62. SMALL CULVERT

of the curves about which the rails are turned. Curvature to the amount of 600 degrees per mile would have the effect of doubling, approximately, the resistance to traction; it would indeed offer about the same resistance to traction as an incline of 1 in 100, and be very much more objectionable—first, because the resistance would be the same both ways; secondly, because the wear would be much more both on rails and wheel tyres.

The interaction of tyres and the rails will be best understood by referring back to 37. The surface of the former, which comes into contact with the top of the latter, is called the *tread*. This is always shaped in the form of a cone. The coning is slight, and not sufficient to be very obvious, but, were the surface of the treads to be extended, a double cone would be formed, having an apex on the outer side of each wheel and in line with the axle. Hence, when running upon a straight portion of the line of way, the wheels will tend to take a central position, with each flange clear of the rail. When running upon a curve, the flange of the wheel on the convex side of the curve will be scraping against the side of the wheel, except so far as this is modified by *superelevation*, which will be explained later. The effect of the wheels being fixed to the axle and thus necessitating the slipping of one of them an inch for every degree of curvature, has already been dealt with in treating of the wear of the rails and length of the rails. This effect is in some degree modified by the coning of the heads, since the portion of the tread in contact with the outer rail is rather larger in diameter than the portion of the tread in contact with the inner rail, and will therefore move further than the latter during a given number of revolutions. Thus on a curve of about half a mile radius there would be little or no slipping from this particular cause. There remains, however, another result of curvature of the line, and by no means the least important. All road carriages have a *locking* arrangement, as it is called—that is to say, the axle upon which the two front wheels are attached, and to which the shafts, or, in a motor-car, the steering-gear is fixed, is movable about a vertical axis. It is sufficient to point out here that the absence on railway trucks, etc., of anything equivalent to the locking apparatus of a road carriage, causes on curves exactly the same amount of scraping and friction with the road as would result from turning a corner with an ordinary four-wheeled vehicle when the locking was jammed fast. While passing round a curve the carriages of which a train is composed form angles with each other, and on any change of curvature or reversion to the straight the buffers of the carriages—when lightly coupled—grind against each other.

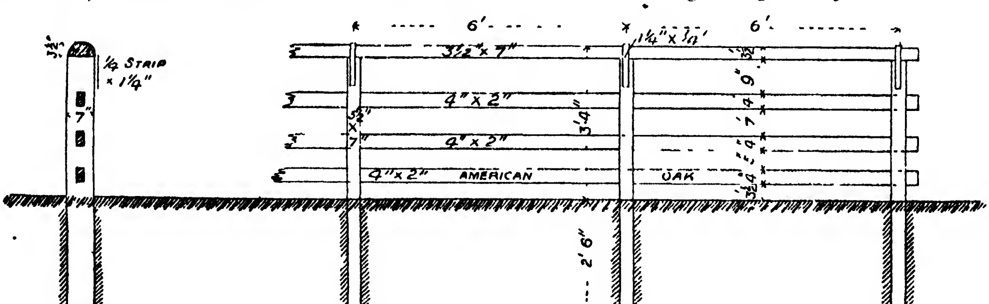


64. SECTION OF WALL

In modern railway design, the numerical results of the effects of curvature upon the capital and annual expenditure is carefully calculated.

Superelevation. According to the first law of motion [see Physics], a train will continue to move on in the same straight line until acted upon by a force sufficient to divert it. On reaching a curve in the line this force is supplied by the pressure of the outer rail of the curve on the flanges of the outer wheels of the train, save as hereinafter explained. It is, of course, undesirable that all the pressure should be provided by pressure on one side of one rail, when by raising the level of the outside rail of the curve sufficiently above that of the inside rail of the curve the needful pressure would be exercised by both rails, and upon their upper surface.

The outer rail of the curve should, therefore, be raised sufficiently that the component of the force of gravitation in a plane parallel to that of the rail-tops shall suffice to divert the path of the train to the degree required by the curvature. The amount by which it is raised is called the *superelevation*. If all trains moved round a curve at the same rate the superelevation could be calculated to fulfil perfectly the conditions above set out, so that the wheels would pass with their flanges equidistant from the rails, as before explained. However, all trains do not move round a curve at the same rate, so a compromise must be adopted according to the traffic conditions. The application of elementary mechanics



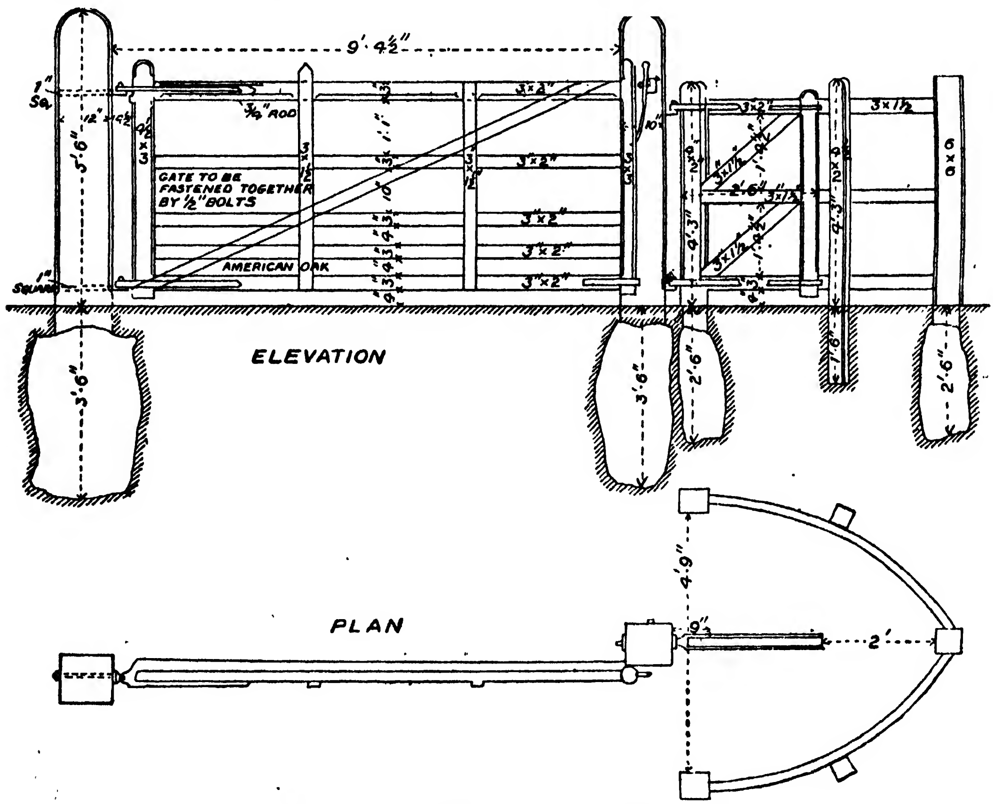
63. COMMON TYPE OF POST AND RAIL FENCE

will show the superelevation for a line of standard gauge to be $\cdot 4 \frac{V^2}{R}$ in feet, where V is the speed of the train in miles per hour and R the radius of the curve in feet. Of course, on curves with an up grade the average speed, and therefore the superelevation, will be less, and where trains are to pass in both directions another compromise must be effected so that superelevation only partially counteracts one source of friction upon curves.

Transition Curves. So far, it has been assumed that the curves of a railway line are throughout the arcs of circles. Now, a circle is a curve of uniform curvation; immediately a train or, rather, a pair of wheels, enters upon a circular curve, it begins to turn, and continues to turn at the same rate until it passes out of that curve. The superelevation ought, therefore, to be as great at the beginning as at any other part of a circular curve. This is seen in the form of the expression for it already given. $\frac{\cdot 4\, V^2}{R}$ depends only upon the speed and the radius of curvature. But the outer rail cannot be suddenly raised 4 in. or 5 in., as the case may be, at the tangent point where the curve begins, or similarly depressed at the end of the curve. The superelevation must, therefore, begin before the curve and be increased upon the curve, being there too much and here too little, and causing a lurching of the train very unfavourable to steady running.

Obviously, therefore, the right thing to do is to begin the curve at tangent point with a circle of infinite radius for which the superelevation would be nothing, and continue it by reducing the radius of curvature and at the same time increasing the superelevation, until the desired radius of curvature and its proper superelevation were gradually attained. The mathematics involved in such procedure is complicated, and though tables have been computed by the help of which transition can be made in this manner, it is more usual to introduce a short cubic parabola between the circular curves and the straight portions of the line wherever required for the safety of the service, or for the comfort of the passengers.

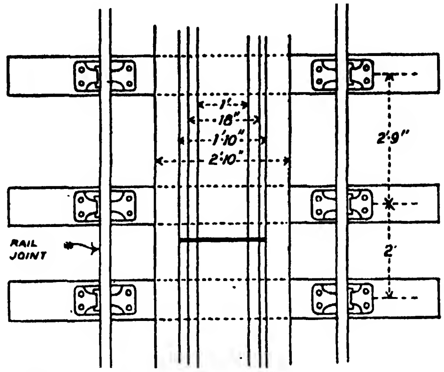
See the articles on Surveying for the means to be adopted to lay out a cubic parabola.



65. GATE AND WICKET FOR LEVEL CROSSING

Waterways. The bridging of rivers and brooks is dealt with in another article. It remains, however, to treat with exceptional rainfall. This is not conspicuous in our favoured islands, but most countries at intervals of 10 years or 20 years (or oftener in the Tropics) are subject to storm-bursts, etc., when water appears in places which are at all other times dry, in quantities

sufficient to demolish long stretches of railroad unless provision has been made to deal with them. To this end the character of the rainfall, the soil, and the area drained must be examined. The question to decide is: How much of the rain falling on one side of the railway must pass it to the other side, and in what time? An inch of rain in 15 minutes is, of course, a very different thing from an inch of rain in an hour, since the latter has four times as long to run away. A porous soil will soak up a lot of rain, whereas a clay soil will allow nearly the whole of it to run off; and the same thing will occur on porous soil if a storm-burst occurs after a rainy period when the soil is saturated. If the drainage area stretched away from the railway a long distance, the water from it will arrive in more manageable amounts than if it were all within a short distance of the railway.



66. PLAN OF RAILWAY WATER TROUGH

Area of Opening. The first rough idea of what area of openings through the line will be needed to carry off flood water may be gained by applying the formula

$$A = C\sqrt[4]{S^3},$$

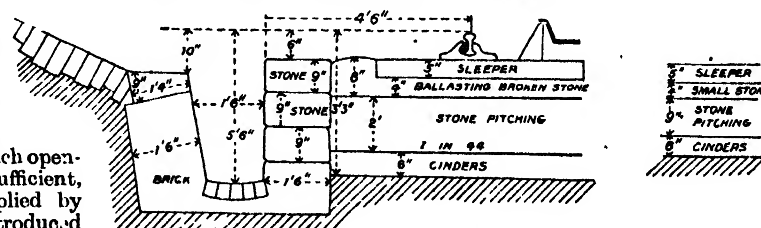
where A is the number of square feet required for the openings, S the area drained in acres, and C a constant quantity; to be taken equal to 1 or ·7 for steep, rocky localities, ·3 for rolling country, and ·2 or less where the drainage area stretches away from the line a distance five or six times its width.

If, then, the area drained were 10,000 acres of ordinary agricultural land the number of square feet of opening required would not be less than 200 ft. or more than 700 ft. This is a very wide margin in which to exercise judgment. In order to narrow it down it will be of great assistance if there are other roads near by the openings in which it may be examined and compared. If such openings have proved sufficient, the value of C implied by their size may be introduced with confidence in the above calculation. Marks left by the high water of previous floods should be carefully sought; in default of similar structures to go by, they will often serve as a guide to the maximum of water to be dealt with.

Culverts. The openings in the line to allow for the appearance of exceptional floods like those for the bridging of small perennial streams, are called *culverts*. Cross-sections of these are shown in 60 and 61. It will be seen that they are of brick, and substantially built, with a strong arch above to transmit the pressure from above, and an invert arch with concrete foundations to distribute the pressure over the earth below. In spite of the latter precaution it will frequently be found that the culverts in a high embankment have been bent downwards in the middle by pressure of the superincumbent earth. Smaller culverts may be built in the manner shown in 62, where the end elevation and longitudinal section as well as the cross-section is shown. Culverts, particularly a culvert of circular section, as this is, may be permitted to run full or even with a *head* as a level of water higher than the height of the inside of the culvert on the up side is called. In general, however, it is best to make the culverts sufficiently large to prevent flood water "backing up" against the railway bank.

Points about Culverts. It is in all cases important to preserve the embankment near the openings of culverts from the erosion of the water entering or leaving them. Thus, wing walls are often provided like those attached to ordinary bridges, but on a smaller scale. In 62 the culvert is shown provided with a flat face, and a channel of stone pitching sloped at 1 in 12 and 12 ft. long, is built at the down end to carry away the water rapidly and safely. The culvert itself should have a slope of 1 in 20. Cast-iron pipes are also useful for small culverts, and those too defective to carry water under pressure are often good enough.

A culvert may sometimes be economically roofed with old iron rails placed contiguously. Indeed, there are a great many uses about a railway to which old sleepers and iron rails may be put.



67. SECTION OF RAILWAY WATER TROUGH

The earth on each side behind the walls of a culvert must be rammed hard and not tipped loosely over it to be consolidated by time and the weight of more earth on the top. Thorough ramming, as described, will relieve the culvert itself of much pressure and serve to sustain it against the tendency to curl beneath the weight of the bank as it settles. If the crown of a

culvert be allowed to approach too near formation level, there is sure to develop a bump which will be very perceptible as an engine passes above it, and which once established is most difficult to cure. The crown of a culvert should, therefore, be kept 3 ft. or more below the formation level.

Fencing. A well-grown hedge forms the most economical fence where the soil, etc., is suitable, but it takes some time to grow. Supplemented by barbed wire to prevent trespass it makes a very satisfactory boundary. Innumerable other forms of fencing are in use. A common type of ordinary post and rail fence is shown in 63. When a wall is necessary, the dimensions given in 64 are necessary and sufficient.

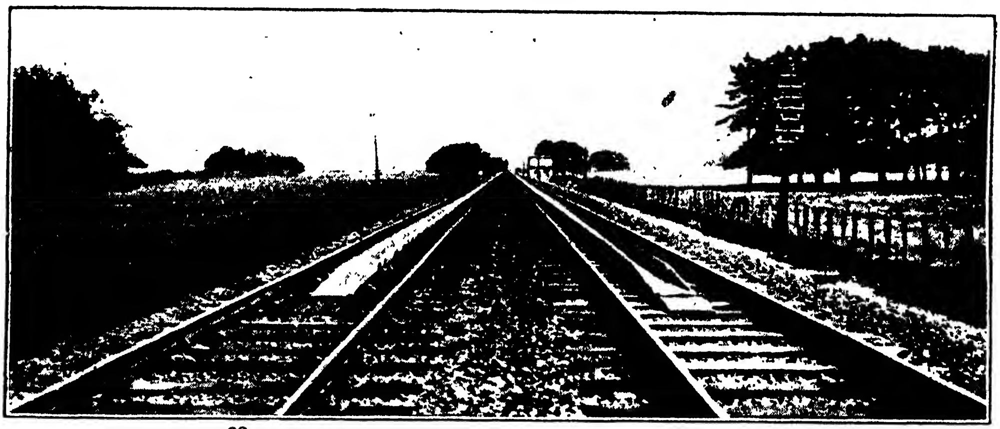
It frequently happens that gates must be provided in the fence to enable farmers' carts, etc., to cross the line. A common example is shown in 65, in which a side wicket is introduced for foot-passengers. It will be noticed that the gate-posts are squared only above ground and the timber beneath is left in the rough. This gives the post a better hold on the ground, and provides a better defence against decay. The wood under ground should also be charred. If the timber below ground is not left rough, charring will weaken it unduly, and the post in this case should be creosoted, as sleepers are. A stout fence may be constructed of old sleepers where these are available. The sleepers of a standard gauge railway being 9 ft. long permit of a fence 5 ft. 6 in. high, 3 ft. 6 in. being under ground. Old rails may also be turned to account in like manner, though there are generally other more useful purposes to which they may be put.

Water Supply. The water consumed in locomotive boilers is a very variable quantity, and depends chiefly upon the work done by the engine. On down grades it will be small, on up grades it will be high, and heavy trains will involve a consumption greater than light trains, by an amount roughly proportional to the difference of weights, supposing that the same length of line is under consideration and the speeds are about equal. Fifty to one hundred gallons per mile are the usual limits, and stations for water supply should be provided at intervals not greater than 16 miles for the lightest traffic, and as close as 10 or 8 miles on roads over which the traffic is heavy. The general question of water supply may be studied in another article.

Track Troughs. On lines where a quick service is necessary, and long distances must be accomplished without a stop, troughs containing water are placed upon the sleepers between the rails. Passing trains are fitted with a scoop which enters the trough while moving and lifts sufficient water to enable the engine to proceed. Illustrations of such a trough are given, the plan in 66, and half-section in 67. The accompanying photograph [68] shows graphically the section of a railway line with two water troughs. Such troughs are usually placed in cuttings where a natural supply of water can be obtained by gravitation.

By the action of the scoop a great deal of it is spilt over the line, and special means must, therefore, be taken for the drainage of the permanent way in these places. The half-section in 67 shows how this may be accomplished. Two feet of stone pitching is provided beneath the ballast, and 6 in. of cinder below the stone pitching where the troughs are placed, while at the side is shown the diminished thicknesses provided for other parts of the same cuttings. Since the surface of the water in the troughs is necessarily level, the rails are made to slope from the commencement of the trough, so that the scoop enters the water automatically. It is made to leave the water by the same means. As to the quality of water required for locomotive boilers it does not differ from that required for other steam-using purpose.

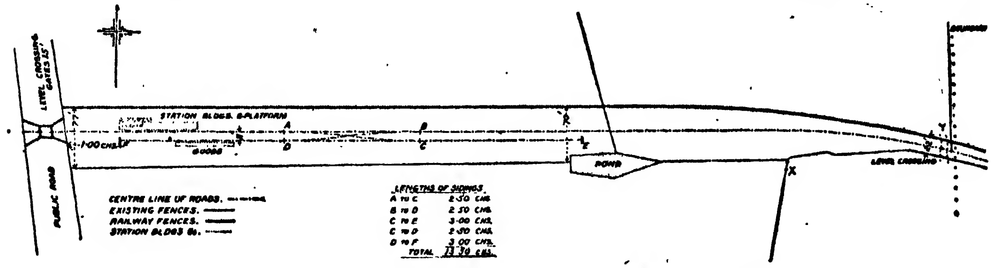
Water Tanks. The water tank on the tender of a locomotive may contain 10 or 20 tons of water, and tanks by the wayside from which the former are to be supplied must be dimensioned accordingly. They should be placed 8 ft. 6 in. from the centre of the nearest track, and about 12 ft. above the level of the rails. It is sometimes necessary



68. SECTION OF RAILWAY LINE WITH WATER TROUGHS

to provide for the injection of steam to prevent freezing, but this applies with most force to the water troughs described.

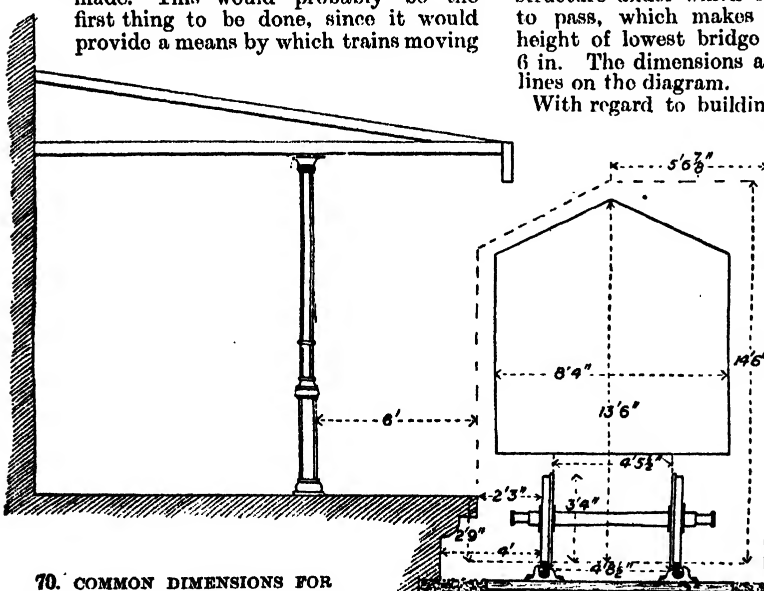
Stations. Large stations are usually situated in large towns, where the arrangements are always determined to a considerable degree by the configuration of the available ground.



69. A TYPICAL SINGLE LINE ARRANGEMENT AT A SMALL RAILWAY STATION

In 69 is shown the arrangement laid out for a wayside station of a single line of standard gauge railway that is in many respects typical. The sidings *c e* and *d f* are long enough to accommodate trains of 15 or 16 trucks, and land is provided to enable extensions to be made when and if they are warranted by future increase of traffic. The siding *c e* might be extended in the direction from *c* to *e* to twice its length, and another junction with the main line then made. This would probably be the first thing to be done, since it would provide a means by which trains moving in contrary directions upon the main line might pass each other with less delay; 11 ft. is the usual distance between the centres of adjacent lines of rails. The width of land taken up, therefore, suffices for two more sidings on either side of the lines of rails shown. The platform is most conveniently made 3 ft. high, measuring from the ballast, though it may be less.

Platform Structures. No structure upon the platform should be less than 11 ft. from the centre of the contiguous line of rails. Other distances commonly observed are given in 70. Here it will be seen that the ordinary width of rolling-stock for a standard gauge railway is 8 ft. 4 in., and its height above rail level 13 ft. 6 in. One foot is allowed between this height and that of the lowest structure under which it should be permitted to pass, which makes the least *headway* or height of lowest bridge above rail level 14 ft. 6 in. The dimensions are shown by the dotted lines on the diagram.



70. COMMON DIMENSIONS FOR PLATFORM AND RAILWAY TRACK

With regard to buildings and other structures at the side of a line, none should approach nearer than 7 ft. to the centre of a line on which passengers are carried at heights above rail level between 12 ft. 6 in. and 11 ft., or, in the case of a goods line, nearer than 5 ft. 6 in. between the same heights. With other gauges and different rolling-stock these measurements will, of course, be modified, but the illustrations afford a concise notion of what has been found necessary and sufficient on lines of the English standard.

R. W. WESTERN

A Dictionary of Technical Terms and Phrases used in Engineering appears at the end of the Self-Educator

The Present Condition of the Novel. Short Studies in Meredith and Hardy. Some of our Later Exponents of Fiction.

THE NOVELISTS OF TODAY

For the present study we have reserved the work of those novelists who were living at the beginning of the twentieth century, and in most cases are still writing, as we are persuaded that there is great need in a work of this kind to insist upon the merits of living writers when so much of our attention must necessarily be drawn to the authors of the past. We have no sympathy with critics who seem never so happy as when they are sneering at the productions of their contemporaries. A very little study of literary history will show that in all ages there have been critics who have maintained this pose. Shakespeare had many detractors in his own day; Scott was not without his adverse critics; Dickens was scoffed at as a writer of low Cockney books. Rather is it desirable to look around us, that we may discover what is good in the work of our contemporaries. And if we but do this today we shall be agreeably surprised to find how excellent is the prose fiction of our living writers.

The Novel a Perfected Instrument. If we have not many giants among us—and this is the most difficult of all things to determine, as we require some distance of time to measure accurately the real dimensions of a great writer—there is no manner of doubt that the general level of excellence represented by the body of contemporary fiction is considerably higher than that obtaining in any former period of our literary history. The novel has become in our own day a perfected instrument. From a formless, lumpish, uncraftsmanlike thing, such as we find it in the hands of even great writers in the past, it has developed into an admirably proportioned and wonderfully effective literary medium.

A Healthy Sign of the Times. What we are saying is that the average good novel of today is as superior to the average novel of the mid-Victorian days as a modern express locomotive is superior to the old "Puffing Billy." This means that the literary art, as distinct from genius—which may be, but is not always, above and independent of convention—has vastly improved from the days of our forefathers. In support of our assertion we have only to examine any representative story by such writers as Mr. Israel Zangwill, Mr. Eden Phillpotts, Sir Arthur Conan Doyle, Mr. Arnold Bennett, Mr. Maurice Hewlett, Sir Gilbert Parker, Mr. Neil Munro, Mr. A. E. W. Mason, and at least a score of other well-known writers, to realise how firm and admirably wrought is the texture of our contemporary fiction as compared with that of any previous period.

The fact that, side by side with what is entirely praiseworthy in the modern novel, there exists a vast amount of fiction that is undeniably trashy, false to every canon of the literary art, useless and often worse than useless as furnishing for the mind, has led hasty critics into unfortunate generalisations condemnatory of the whole body of contemporary fiction. In all times, and everywhere, the weeds have flourished as luxuriantly as the flowers—often more profusely. It is so today in the world of letters, but not more so than at any time in the past. That so many of our best living novelists are widely and intelligently read by an ever-increasing public is of far more importance than the fact that an immense number of superficial writers secure large circulations for their works by the patronage of the uncultured.

George Meredith. There is, of course, a sense in which the two great novelists of the period under notice, Mr. Meredith and Mr. Hardy, should have come into our previous study. As writers of fiction, both may be said to have ended their careers before the twentieth century.

Stevenson owed a great deal to George Meredith (b. 1828; d. 1909); and this fact may be taken as specially significant. Though his first book, a volume of poems, was published in 1851, Meredith did not begin to be appreciated by the public till quite thirty years later. Though there now exists a Meredith cult, it cannot be affirmed that its "idol" is popular. We may reasonably doubt if he will ever be read as widely as, say, Thackeray, or if he will ever become a "classic." But to the student of contemporary English fiction Meredith is something greater than a popular writer. He was a great influence. Stevenson counts but as a unit among those who were or will be influenced by him. There are various reasons for the power he has exerted. The chief reason is that he chose to look at life with his own eyes, and to describe it in his own words. The life he depicts may not be the life with which we are all familiar. His people are, as he has described them, "actual, yet uncommon." Meredith is a social satirist. Full often he smites and spares not. But it is scalpel work, never mutilation. He was a poet before he was a novelist, a philosopher before he was a poet, and his novels are poetry and philosophy combined. His place is with Browning and Carlyle. They and he have the defects of their qualities. But what splendid qualities these are! Meredith is thought-compelling. He gives exercise to the mind. He is a fellow-traveller on life's journey who gives readily from a store of experience that is vastly greater than our own.

How to Study Meredith. Some of us have not yet learnt that we get no more from a book than we bring to it. The Meredithian

mind is an intellectual Golconda. The right way to "work" it is to study the man and find out the origin and motive of his writings. None of Meredith's novels can be fully appreciated at a first reading. Knowledge, as well as industry, is essential. How, for example, can "The Tragic Comedians" be understood unless the reader know something of the career of the German Socialist Lassalle? But the diligent student will find Meredith to a very considerable extent self-critical and self-explanatory. As to his style, this is admittedly difficult; it is like a river with many tortuous windings but noble reaches. But his English, at its best, is the best English of his time. He is to be studied, not imitated; and the study should result in a disregard for the iteration of toil-worn phrases. "A writer," he says, "who is not servile and has insight must coin from his own mint."

Meredith's Style. It has been very happily said of him that "he thinks in metaphor," which is precisely what the ruck of mankind does not do. Hence, it is not surprising that to the average reader the works of this great novelist should present grave difficulties of style. Curiously enough, we find his poetry presenting a clearness and grace of diction, a simple beauty of words, which is nearly always foreign to his prose manner. The late Ashcroft Noble observed with much truth that "his speaking voice is an affair of organisation; his singing voice is the result of careful training." In other words, Meredith the novelist tells his story in a manner natural to the man; but in his poetry the conscious artist, under the restraint of his medium, has to rid himself of the perpetual involutions of metaphorical thought which are natural to him and characterise his work in prose.

Begin with "Richard Feverel." There can be no question that the best of Meredith's novels to begin with is "The Ordeal of Richard Feverel." If we ask "What is education?" we have here an answer equivalent to many debates in Parliament and many speeches on political platforms. We have education not merely described but seen in action. If we ask "What is love?" "What passion?" we have but to take up "Richard Feverel" to see these two dominating attributes of our common human nature set forth with a freshness, a vigour, a reverence, a sympathy, a feeling for external nature—with a knowledge, in short—unrivalled by any other writer of contemporary fiction. If we seek an example of the analysis of motive we cannot do better than study, and we shall be the better for studying, the dissection of Sir Willoughby Patterne in "The Egoist," in modern fiction surely the most finished portrayal of any type of character, an "uncommon" character in which every readers will find some phase of his own self revealed to him. "Beauchamp's Career," "Diana of the Crossways," and "The Adventures of Harry Richmond" are the best of Meredith's other novels; "The Shaving of Shagpat" the most richly imaginative. To show that genius, if not always "the art of taking pains," and does not despise drudgery, it may be sufficient to mention that for thirty years Meredith was literary reader to a well-known firm of publishers.

Thomas Hardy. If with Browning and Meredith we believe that

"God's in His heaven;
All's right with the world!"

a study of the novels of THOMAS HARDY (b. 1840) will be a somewhat mixed pleasure. Hardy, even more than Meredith, has great dramatic qualities. But Hardy's is the voice of the countryside—of the countryside that is far removed from town. To him the greenwood tree suggests not merriment, but destiny; a pair of blue eyes not heaven, but Fate. Life is a tragedy with a few interludes. The coast of Dorset might almost be the shores of old Armorica. Yet the philosophy of this Dorset seer is stern, not weeping. The words of religion are quoted freely in his novels, but in the spirit of the educated pagan. The peasants he introduces to us belong to a part of England the exclusiveness of which is only now being broken into. Their ways and modes of thought are depicted with a realism that is pitiless, though the novelist lightens his narratives with many a flash of genuine humour. Hardy is a writer who must be approached with an understanding of his own environment, which is the environment of the characters of his novels. The student must gain the novelist's point of view; then, even in the case of "Jude the Obscure," in place of the repulsion that many might otherwise experience, simple admiration of the writer's art will be awakened. This art is undoubtedly circumscribed, but it is great art, nevertheless. Every incident in the novels written by Thomas Hardy is calculated with unerring skill; the movement is controlled from the outset with the deliberation of conscious art. The style is as direct as the plot; its distinction is derived from its subject-matter.

Hardy's Best Novels. With Hardy, style without thought is mere vanity. "A writer's style," he once wrote, "is according to his temperament; and my impression is that if he has anything to say which is of value, and words to say it with, the style will come of itself." Like Meredith, Hardy is a poet; like him, again, he is scarcely a "popular" author, though both have received in more recent years far more public favour than in the prime of their lives. We have said enough, perhaps, to show that he is an important novelist for the student. His best work appeared in the following order: "Under the Greenwood Tree" (1872), "A Pair of Blue Eyes" (1873), "Far from the Madding Crowd" (1874), "The Return of the Native" (1878), "The Mayor of Casterbridge" (1886), "The Woodlanders" (1886-7), "Tess of the D'Urbervilles" (his greatest novel, 1891), and "Jude the Obscure" (1894-5). The reader would do well to take up his novels in this sequence, but his always popular story "Far from the Madding Crowd" may be confidently regarded as most representative of his art.

The Test of a Novel. At this point we think it well to define more particularly than we have yet done the supreme quality of a good novel. We have in our previous study seen that the melodramatic story is one in which incidents are of first importance. Human nature, the facts of life, do not concern writers of this class of fiction. Their chief stock-in-trade is the "thrilling situation." True, in life there are many incidents as thrilling as any ever invented by the most ingenious sensation-monger, but the difference lies in the fact that the great episodes of life, like the great rivers of the world, have their source in little things, and convey no lesson to us unless we know something of the source from which they spring. In all works by masters of fiction it will be found that the "supreme moments," the crises which they describe, have grown steadily, remorselessly, fatefully, out of the lives of their "dramatis personæ," and have not been invented merely to "thrill" or shock the reader. This does not mean that the supreme moment must come late in the story; it may occur early in the narrative; but when such is the case it will be found to dominate the entire book, to shape and colour everything that follows.

The "Inevitable" Incident. If the reader will turn to "Far from the Madding Crowd," he will find that the fifth chapter contains one of the most tragic episodes in modern fiction, related in a simple, unaffected style, but coming like a peal of near thunder on a summer day, startling, portentous, "thrilling" if you will, but absolutely inevitable in the drama the novelist is unfolding. It tells how Gabriel Oak, the young farmer who is the hero of the story, has come within sight of his long-toiled-for success, and has thoughts of marriage, when, one night, he is reduced to ruin by the misguided zeal of a sheep-dog, which drives some two hundred of his flock, whose lambs have not yet come, into a chalk-pit. "The sheep were not insured. All the savings of a frugal life had been dispersed at a blow. . . . It was as remarkable as it was characteristic that the one sentence he uttered was in thankfulness: 'Thank God I am not married! What would she have done in the poverty now coming upon me?'"

DORCHESTER, THE MARKET TOWN OF WESSEX, IMMORTALISED BY THOMAS HARDY

This tragic episode is described with perfect literary art and fidelity to life. It keys the whole story through the fifty-odd chapters that follow. It exercises a mighty influence on the character of the hero and his relations with the other persons of the romance. It is essential to the story, woven into the web of it, impossible to be removed without ruin to the whole. That is what we mean when we speak of the incidents

in the works of great novelists as being "inevitable." When the reader thoroughly appreciates this, he will have no difficulty in distinguishing between the novel of true character and drama and the novel of false character and melodrama.

Kipling's Place as Novelist. One of the principal features in the fiction of our time is its note of social criticism, especially in regard to women. Mr. RUDYARD KIPLING (b. 1865), touched this note in "The Light that Failed," but Kipling is to be found at his best in his short stories of Anglo-Indian life, "Kim," and his outdoor books for children. In his prose as well as in his ballads he has depicted the Cockney soldier abroad with unerring insight and fidelity. His prose fiction is as worthy of serious study as that of any master of the near past. Whether his opinions please or irritate us, we must acknowledge that he possesses an absolute individuality in his style; that he is a "maker" and not a mere journeyman of letters. The clash of rival forces and the mystic spirit of the dreaming East have found reflection also in the work of Mrs. FLORA ANNIE STEEL (b. 1847), particularly in "On the Face of the Waters" and the short stories published under the title of "In the Permanent Way." The bitterness of outlook in the novels of Thomas Hardy is more than equalled in "The Story of an African Farm," written by Mrs. OLIVE SCHREINER when she was quite a girl. Revolt, too, though of a more temperate kind, is a characteristic of the novels—"Marcella," "The History of David Grieve," and "Robert Elsmere"—of Mrs. HUMPHRY WARD (b. 1851), a granddaughter of Arnold of Rugby, and a writer whose work claims consideration with, as it is influenced by, that of George Eliot and Charlotte Brontë.

The "Society" Novel. What is called the "society novel" includes among its writers Mr. E. F. BENSON (b. 1867), author of "Dodo" and "Mammon & Co."; Mr. F. C. PHILIPS (b. 1849), author of "As in a Looking-glass"; Mr. PERCY WHITE, author of "Mr. Bailey-Martin," "The West-End," and "Andria"; "Benjamin Swift" (Mr. WILLIAM ROMAINE PATERSON) (b. 1871), author of "Nancy Noon" and "Ludus Amoris"; Mr. JOHN A. STEUART (b. 1861), author of "Wine on the Lees"; Mr. WILLIAM J. LOCKE (b. 1863), author of "Derelicts," who has made great advances in recent years; Mr. EDWIN PUGH (b. 1874), author of "Fruit of the Vine"; Mr. LEONARD MERRICK (b. 1864), author of "The Man Who Was Good" and "The Worldlings"; "Ouida" (Mlle. de la RAMEE), author of "Moths" and "The Waters of Edera"; Miss Braddon (Mrs. JOHN MAXWELL) (b. 1837), author of "Lady Audley's Secret"; Mr. W. B. MAXWELL, a son of the last-mentioned writer, author of "Vivien," "The Ragged Messenger," and "The Guarded Flame," all works of distinction.

Mr. H. G. WELLS (b. 1866), in addition to writing a series of remarkable semi-scientific, half-sociological works, which have caused him to be compared to both Jules Verne and Herbert Spencer, has in "Kipps" penned a social satire of exceeding power. Miss VIOLET HUNT, author of "A Hard Woman," "The Celebrity at Home," and "Sooner or Later," and Miss BEATRICE HARRADEN (b. 1864), author of "Ships that Pass in the Night" and "Hilda Strafford," are writers whose works are representative of the mingled satire and brilliant pessimism which is to be found in the books of many women novelists.

Realists and Others. Among those who have sought, somewhat after the method of the French school, to photograph humble life may be cited Mr. ARTHUR MORRISON (b. 1863), author of "Tales of Mean Streets"; Mr. GEORGE MOORE, author of "Esther Waters," and an acknowledged pupil of Zola; WILLIAM SOMERSET MAUGHAM (b. 1874), author of "'Liza of Lambeth"; and Mr. RICHARD WHITEING (b. 1840), author of "No. 5, John Street." In "The Passport," Mr. RICHARD BAGOT (b. 1860) has written a brilliant exposure of Vatican intrigue; and religion and ethical questions are dealt with by Mr. WILLIAM HURRELL MALLOCK, Dr. WILLIAM BARRY (b. 1849), "Mark Rutherford" (Mr. WILLIAM HALE WHITE) (d. 1913), and Mr. F. T. BULLEN (b. 1857). Questions of the day form the theme of such purely "popular" writers as Mr. HALL CAINE (b. 1853) and Miss MARIE CORELLI. Mr. COULSON KERNAHAN (b. 1858) has achieved distinction in the department of allegory; Mr. HAROLD BEGBIE (b. 1871) has distinguished himself in many veins; Mr. ROBERT HICHENS (b. 1864), who produced a striking society novel in "The Woman with the Fan," also in "The Black Spaniel" touched the macabre vein, so distinctive of the work of Mr. ARTHUR MACHEN (b. 1863), author of "The House of Souls."

Modern Romance. In the realm of historical romance, prominent places are claimed for Sir ARTHUR CONAN DOYLE (b. 1859), author of "The White Company" and "Uncle Bernac," and the creator of "Sherlock Holmes"; Mr. STANLEY WEYMAN (b. 1855), author of "A Gentleman of France," "Under the Red Robe," and "My Lady Rotha"; Sir GILBERT PARKER (b. 1862), author of "The Seats of the Mighty"; Mr. ANTHONY HOPE (HAWKINS) (b. 1863), author of "The Prisoner of Zenda" and "Quisanté"; Mr. MAURICE HEWLETT (b. 1861), author of "The Queen's Quair" and "The Forest Lovers"; Mr. S. LEVETT-YEATS, author of "The Chevalier d'Auriac"; Mr. S. R. CROCKETT (b. 1860; d. 1914), author of "The Red Axe" and "The Raiders"; Mr. BERNARD CAPES, author of "A Castle in Spain"; "John Oliver Hobbes" (Mrs. CRAIGIE) (b. 1867; d. 1906), author of "A School for Saints" and "Robert Orange"; "M. E. Francis" (Mrs. FRANCES BLUNDELL), author of "Yeoman Fleetwood"; and Mr. F. FRANKFORT MOORE (b. 1855), author of "The Jessamy Bride." Romance pure and simple and fascinating marks almost every book that has come from the pen of Mr. and Mrs. EGERTON CASTLE,

joint authors of "Young April" and "If Youth but Knew." The quality of a rare humour distinguishes the stories of Sir JAMES M. BARRIE (b. 1860), stories that stand quite by themselves, as "The Little Minister" and "The Little White Bird," and the short sketches collected in "A Window in Thrums" and "Auld Licht Idylls." The romance of adventure in Far Eastern seas has found in Mr. JOSEPH CONRAD (joint author with Mr. F. M. HUEFFER of "Romance") a skilful interpreter. Mr. LOUIS BECKE (b. 1848) transports the reader to the islands of the Southern Seas, as in "Rodman the Boatsteerer"; while Mr. R. B. CUNNINGHAME GRAHAM (b. 1852) has written with masterly touch of the romance of life in South America, as in "The Ipané." Australian life is reflected in the books of "Rolf Boldrewood" (Mr. T. A. BROWNE) (b. 1826) and Mr. E. W. HORNUNG (b. 1866), author of "The Rogue's March" and "A Bride from the Bush." Mr. MAX PEMBERTON (b. 1863) has won wide popularity by his novels of pure adventure, a vein also profitably worked by Mr. C. J. CUTCLIFFE HYNE (b. 1866). South Africa as a field of adventure has been exploited to some purpose in the highly coloured pages of Mr. H. RIDER HAGGARD (b. 1856), author of "King Solomon's Mines," "She," "Ayesha" (an old title revived), and "Stella Fregelius." The roving spirit is well expressed in the work of Mr. MORLEY ROBERTS (b. 1857). Mention must also be made of the fine works of Sir A. T. QUILLER-COUCH (b. 1863), author of "Troy Town" and "The Splendid Spur"; Mr. THEODORE WATTS-DUNTON (d. 1914), author of "Aylwin"; Mr. CHARLES MARRIOTT (b. 1869), author of "The Column" and "Genevra"; Mr. A. E. W. MASON (b. 1867), author of "The Courtship of Morrice Buckler" and "The Four Feathers"; Mr. JOHN OXENHAM, author of "John of Gerisau" and "Barbe of Grand Bayou"; Mr. R. H. BENSON, author of "The King's Achievement"; and Mr. W. H. HUDSON. There is also much to admire in the writings of the Rev. S. BARING-GOULD (b. 1834), whose "Mehalah" has been widely read; Mr. NEIL MUNRO (b. 1864), author of "John Splendid"; Mr. DAVID STORRAR MELDRUM (b. 1865), author of "The Story of Margrédel"; "Zack" (Miss GWENDOLINE KEATS); DAVID CHRISTIE MURRAY (b. 1847; d. 1907); Mr. W. E. NORRIS, author of "Giles Ingilby"; Mr. EDEN PHILLPOTTS (b. 1862), author of "Children of the Mist" and "The Secret Woman"; Mr. HALLIWELL SUTCLIFFE (b. 1870), author of "Ricroft of Withens" and "Through Sorrow's Gates"; Mr. W. C. CLARK RUSSELL (b. 1844; d. 1911), author of "The Wreck of the 'Grosvenor'"; Mr. LAURENCE HOUSMAN (b. 1867), author of "An Englishwoman's Love Letters" and "A Modern Antæus"; Mr. ISRAEL ZANGWILL (b. 1864), author of "Children of the Ghetto"; Mr. HUGH WALPOLE, Mr. ARNOLD BENNETT (as popular as a playwright as a novelist), Mr. R. MURRAY GILCHRIST, Mr. JEFFREY FARNOL, and Mr. J. H. M'CARTHY.

Humour has admirable representatives in "F. Anstey" (Mr. F. A. GUTHRIE), Mr. W. W. JACOBS (b. 1863), Mr. BARRY PAIN, and Mr. W. PETT RIDGE. Mention must also be made of the success of Mr. JOSEPH HATTON (b. 1840; d. 1907), while Mr. JEROME K. JEROME (b. 1859) has proved himself a novelist of great power and insight.

Some Prominent Women Novelists. "Lucas Malet" (Mrs. MARY ST. LEGER HARRISON), in "The History of Sir Richard Calmady," made a reputation for power at the expense of more admirable qualities, but the book will not readily be forgotten. Other prominent women writers are Miss RHODA BROUGHTON (b. 1840), author of "Cometh Up as a Flower"; Mrs. KATHARINE TYNAN HINKSON (b. 1861); Miss JANE BARLOW, author of "Irish Idylls"; Miss M. BETHAM-EDWARDS, author of "Dr. Jacob"; Miss MARY CHOLMONDELY, author of "Red Pottage"; Miss UNA L. SILBERRAD (b. 1872), author of "The Wedding of the Lady of Lovell"; Miss MAY SINCLAIR, author of "Divine Fire"; "Maxwell Gray" (Miss M. G. TUTTIETT), author of "The Silence of Dean Maitland"; Miss E. T. Fowler (Mrs. A. L. FELKIN), author of "Concerning Isabel Carnaby"; "Sidney C. Grier" (Miss GREGG) (b. 1868), author of "Like Another Helen"; Mrs. W. K. CLIFFORD; "Rita" (Mrs. W. DESMOND HUMPHREYS); Mrs. L. B. WALFORD (b. 1845), author of "The Mischief of Monica"; Miss HELEN MATHERS (b. 1853), author of "Comin' Through the Rye"; Mrs. KATHARINE S. MACQUOID; and Mrs. CAMPBELL-PRAED (b. 1852).

The Literary Life. With this very brief glance at the more recent novelists, we have arrived at the end of our study of English prose fiction, and, indeed, within sight of the end of this course in English Literature, for what is to follow is merely in the shape of appendices, in which we shall endeavour to give in the briefest outline some courses of reading in classical, foreign, and American literature. Most of the other courses in the SELF-EDUCATOR are concerned with the direct application of knowledge to the daily conduct of life and business. This course in Literature has been designed chiefly for the general reader, that it might aid him to the intelligent study of our great writers and those writers who, though falling short of greatness, have still something to tell that will add in some measure to his intellectual enjoyment. The career of the professional man of letters is in some ways the noblest and the most attractive of all, but the way to it lies through much tribulation, and is not lightly to be entered upon, unless the aspirant has as clear a "call" for the work as the candidate for the pulpit is supposed to have. We have made it no part of our business to indicate to the literary aspirant what his course of action should be, but in the course on Journalism, which immediately follows that on Literature, the aspirant will find how the door may be opened that leads to success in literature. For it is worthy of note that by far the largest number of authors whose names are familiar to the reading public have made their way to reputations in literature through the humbler but more easily opened door of journalism.

J. A. HAMMERTON

Conditions of Entry and Service in Clerical and Administrative, Railway, and Police Appointments in British Colonies. The Colonial Services.

STATE SERVICE IN THE COLONIES

As a general rule, the young Briton in quest of a career in some portion of our Empire oversea would be well advised to turn his attention to private enterprise, whether farming, mining, commerce, or the professions, rather than to seek the services of the Colonial Governments. A moment's reflection will suffice to show the reason of this. Most of the governing bodies, it has already been pointed out, can obtain from local sources an ample supply of suitable material, and have, therefore, no need to turn to the Mother Country for recruits. This is especially true in respect of the larger and older branches of the Empire—Canada, South Africa, Australia, and New Zealand, for example—in which a new generation has sprung up on the soil to contest with immigrant residents such vacancies as arise from time to time in the official ranks.

An Authoritative Warning. These facts have led the Emigrants' Information Office, a Government bureau controlled by the Colonial Department, to issue a warning on the subject. In the preface to its "Handbook on Professional Employment in Canada, Australia, New Zealand, and South Africa"—a very valuable work, which may be obtained, post free, for threepence, from 34, Broadway, Westminster, S.W.—it is officially stated that "Candidates from this country stand very little chance against persons on the spot of obtaining appointments in the Civil Service. Even telegraphists, railway officials, and employees are now generally trained locally. There is, therefore, very little inducement for a person to emigrate on the chance of obtaining an appointment under a Colonial Government."

Apart from India and our Eastern possessions, which have been specially considered, the principal exceptions to the above general rule arise where certain Colonies, owing to the lack of training centres, the smallness of their white population, or other local causes, are unable to furnish enough qualified candidates for their own requirements. We shall therefore pass in review the various openings thus afforded to aspirants from Great Britain, and for our readers' convenience these will be discussed calling by calling, instead of grouping them according to locality.

Clerical and Administrative Posts. In this branch of the public service there is practically no Colonial demand for British candidates, and in general no opportunity is afforded them of obtaining an appointment before quitting the home country, while in several instances they are specially excluded in favour of local applicants. There is, however, an important exception on behalf of students from the British Universities who have failed to pass the contest for the Indian Civil or Police Services, or for Eastern Cadetships. These candidates may often secure good appointments on the West African Coast, or elsewhere, by applying to the Colonial Office, Downing Street, S.W. The posts thus available include cadetships for the grade of assistant district commissioner for the Gold Coast, with an initial salary of £250 and excellent prospects up to £2000 or more. Such students are also selected sometimes by the Foreign Office for administrative posts in Egypt and British East and Central Africa, and by the British South Africa Company for their Rhodesian territory.

On the other hand, the clerical service of Canada is practically restricted to persons brought up in the Dominion, or able to enlist local influence on their behalf. The Government regulations in Queensland require candidates for ordinary appointments to have resided for twelve months in the State; in South Australia two years' residence is the minimum. The New Zealand authorities expressly seek to dissuade applicants from going out to that country with the idea of entering its clerical service; and other Colonies are no less discouraging. Inquirers are generally informed that preference is given to local applicants, and that numbers of such candidates are already awaiting appointments. Incurable optimists who are not daunted from emigration by these and similar reports will find in the "Professional Handbook" the conditions of entrance for the clerical service of the various Colonies.

Railway Posts. Instead of being private enterprises, as in this country, the great majority of Colonial railways belong to the Governments, and, despite the allusion to railways already quoted from the "Handbook," these offer very much better chances of employment for a trained official than are afforded by the clerical services.

To enumerate here the various rates of pay for railwaymen in each of the likely Colonies would occupy an unwarrantable space. These figures can be learnt on application to the Emigrants' Information Office, or to the several Colonial agents in London. The former also issues, gratis or at nominal prices, a valuable series of circulars in which the current wages and the demand in each Colony are set out. For our present purpose, a brief indication of the prospects afforded to men from home will suffice.

South Africa. On the State railways in the South African Union there is no demand for office clerks, but drivers and firemen, guards, signalmen, and mechanics are sometimes engaged

in England by means of advertisements in the daily press. The engagements are usually for three years, with payment of the passage out. The daily wages are, for drivers, 10s. 6d. to 15s.; guards, 8s. to 11s.; signalmen, 7s. 6d. to 12s. But it must be remembered that the purchasing power of money is much less in South Africa than at home. There is considerable risk in going out without a definite prospect of employment. On the other hand, experienced men who have gone out at a venture have as good chances of engagement as those who are Colonial born.

Australia. The rates of pay for railway employees in Australia and New Zealand are generally good, and the hours of duty light—from 48 to 57 weekly—but from every part of the Colony there comes practically the same report of the sufficiency of local candidates. The construction of the new railway between Port Augusta and Kalgoorlie, however, will probably afford some useful openings for trained men in South Australia, alike in the traffic and the locomotive staff. As a general rule, candidates for permanent employment must be under 35 years of age, and able to pass a medical examination. For clerks and superior officers an educational test is also usually prescribed.

In West Africa vacancies occur from time to time for station-masters, guards, platelayers, and others, as well as for engine and carriage builders. The rates of pay are high, guards and foremen platelayers and fitters receiving £200 a year; and free passages are provided. The minimum age is generally 23 years. Application should be made to the Crown Agents for the Colonies, Whitehall Gardens, S.W.

The Canadian railways, like those under the Southern Cross, are officially reported to afford "little or no opening for men from England." But such announcements are intended only to discourage anything like a general movement to the regions concerned. Casual vacancies occur for which capable men who have been trained on British railways are in frequent request; and while an engagement before leaving home is highly desirable—and for heads of families is, indeed, imperative—these warnings need not daunt an efficient young railwayman without encumbrances from trying his fortunes there. He should not take such a step, however, unless he has a little capital on which to live while seeking a post, nor without consulting the experts of the Emigrants' Information Office as to the likeliest field of employment.

THE NORTH-WEST CANADIAN POLICE

THE BRITISH SOUTH AFRICA POLICE

Police Appointments. Our Colonial police are in some few instances municipal servants—as at Cape Town and Durban, for example. Most of the townships, however, are too small and scattered to maintain separate forces, and police control is therefore usually exercised by the Government of the Colony.

The life of a police trooper in the Colonies is at least as hard as in the home country, his prospects of promotion are generally but little better, and the increased cost of living often renders his higher wages an apparent rather than a real advantage. On the other hand, the

semi-military duties of many Colonial forces, the chances they offer of sport and adventure, and that "call of the wild" which the great, lonely spaces of the Empire utter to the imaginative ear, give these services an attraction not to be measured in terms of self-interest, and draw into their ranks many men whom the prospect of town or provincial police duty at home would repel.

South Africa. In 1912, the various provincial forces of the Union were reorganised into two bodies. The first of these, the South African Mounted Rifles, is a semi-military force included in the South Africa Defence Scheme; the other, known as the South African Police, performs ordinary police duties and is divided into a mounted and a foot branch. The limits of age are 18 and 27 for the former, and 18 and 35 for the latter force. In both the period of enlistment is three years, and the commissioned ranks are filled by promotion. Recruiting in this country is for the present suspended for both forces.

Rhodesian Forces. The British South Africa Police (which must be distinguished from the South African Police mentioned above) are a mounted force employed, under the control of the Imperial Government, in maintaining order in Southern Rhodesia and Bechuanaland. Non-commissioned officers and men are recruited, as a rule, in England. Recruits must be at least 20 years of age and—unless they have served in another police force—not more than 25. They must be of good character, able to ride and shoot, between 5 ft. 6 in. and 5 ft. 10 in. in stature, and of proportionate build. Officers are occasionally sent out from England, but are usually selected from the non-commissioned ranks. The rates of pay are as follows: Troopers, 5s. a day; sergeants, 6s. to 8s.; sergeant-majors, 12s. 6d.; commissioned officers, 15s. 6d. to 30s. and upwards—in each case with free quarters and rations. Men enlisted from this country are required to pay their own passage as far as Cape Town.

Further particulars may be had of the British South Africa Company, 2, London Wall Buildings, E.C., who will always inform applicants whether recruiting is proceeding in England.

Cape Town and Durban Police. Constables in the Cape Town corps are paid £110, £125, and £140 during the three years of their engagement, with free quarters and uniform. Recruiting is mainly local, but smart members of English forces are generally eligible; and as promotion is speedy, ambitious young officers from the Mother Country sometimes effect a transference to the Cape. The Durban Police Force is available to suitable applicants from the United Kingdom, the conditions of entrance prescribing 5 ft. 9 in. as the minimum height and 35 as the maximum age. Preference is always given to unmarried men. Candidates from this country should write for instructions to the Superintendent at Durban. The pay is £132 a year for constables, rising in two years to £144; and sergeants receive £162. Messing and quarters cost about £4 a month.

Australia and New Zealand. In the Australian States, as in New Zealand, candidates must apply personally at the police headquarters in each Colony, and there is no demand for men from England unless they have had previous police experience and are of exemplary character. It would therefore be useless to detail the conditions of service in the several forces; they may be found by the curious in the Emigrants' Handbook, to which we have already referred.

Canada and the N.-W. Mounted Police. The Royal North-West Mounted Police Force, however, is more readily accessible to English candidates. This distinguished police corps attracts more British than Canadian recruits; and although all would-be entrants must present themselves in the Dominion for enlistment, a wise provision of the Commissioner enables them to make fairly certain of their chances before incurring the expense of the journey. On applying to that official at Regina, Sask., a blank medical certificate can be obtained, together with information as to the existence of vacancies, the standard of requirements, and the terms on which troopers are engaged. By returning the medical form filled in by a local doctor, a candidate residing in the United Kingdom can ascertain from the authorities his prospects of acceptance or rejection on the score of health.

The terms of service admit only single men between the ages of 22 and 30 who are active and able-bodied, and of excellent character. They must be able to read and write, and must understand the care of horses, and be good riders. The minimum height is 5 ft. 8 in., the chest measurement must be 35 in., or more, and the weight must not exceed 175 lb. Constables are enrolled for five years, and receive 1 dol. a day, rising to 1 dol. 25 cents., with rations. Non-commissioned officers draw from 1 dol. 50 cents. to 2 dol. 50 cents. a day.

A high official of the force has very courteously sent us the following useful remarks for the benefit of prospective candidates. "Applicants must be perfectly sound from a medical standpoint, and have certificates of exemplary character. Intending recruits have to report at Regina at their own expense, and be prepared to undergo a very strict medical examination by our own surgeon. They must assume all risks. Young men of about 22 years of age, well educated and of strictly temperate habits, are most suitable for our service. In fact, intemperance is suppressed with a stern hand."

The Crown Colonies and Uganda. Candidates for police posts in Uganda or the East African Protectorate should apply to the Secretary of State for the Colonies. The appointment of officers of the smaller police forces of the Crown Colonies is in the hands of the same official, and application should be made to his private secretary at the Colonial Office. The rank and file in all these Colonies are, of course, natives.

ERNEST A. CARR.

The Astonishing Effect of Ultra-Violet Light on Bacilli. Conditions Affecting Germ-Plasm.

GERM CELLS AND ENVIRONMENT

For the answer to the ultimate questions, Mendelism has failed us, as we have seen. Nevertheless, we are a stage further, in that Mendelism has shown, more clearly than ever, where the problem lies. It is in the germ-cell. The "factors" about which we have heard so much exist in the germ-cell, and have somehow been formed there. If we are to discover the origin of variations, or the "origin of a 'dominant,'" we must study germ-cells; and, above all, we must try to discover any *evidence that external conditions affect them.* This is an inquiry to which none of the Mendelians has yet given a moment, but it evidently lies far deeper, and matters immeasurably more for organic evolution, than any studies of the behaviour of factors already existing.

At this point we require to consider a new discovery, the most important of its kind that has ever been made, which seems at first sight far remote from the present discussion. We shall leave the higher forms of life, with their two sexes, each producing germ-cells that unite to form a new multicellular organism, and we shall devote ourselves to some of the humblest bacteria, single-celled, asexual organisms, the lowest visible in the scale of life.

For some strange reason, bacteriologists have in general been the sternest upholders in our own day of that doctrine of the fixity of species which it was the chief intellectual achievement of the nineteenth century to overthrow. Any one of them would indignantly repudiate that doctrine in general, but, in fact, would stoutly maintain the constancy of type among the various species of bacteria. This doctrine is not merely academic. Half the practice of public health in this and other civilised countries depends upon the belief that the bacteria of disease breed true, and that innocent bacteria cannot be suddenly and violently transformed into noxious ones. Practically speaking, those ideas may be true and salutary, but pure science now has cognisance of a new fact which will doubtless be only the first of a long series that may transform bacteriology, as we at present know this fascinating study.

Effect of Ultra-Violet Light on Bacilli. Working in the Pasteur Institute, a bacteriologist named Madame Victor Henri has succeeded, within the last few months, in obtaining unheard-of and sensational results by very simple means. The facts are by now well vouched for, and have been announced to the world by Professor Roux, the director of the Pasteur Institute and the famous part-maker of the diphtheria antitoxin. Madame Henri worked with the well-known bacilli of anthrax, which are comparatively large, and were the first bacteria of any kind to be incriminated as the cause of disease. These bacteria are of the kind consisting of "little rods"—hence the name bacilli. Their shape is very constant and characteristic. Any young student learns in a day or two to recognise these well-defined and unmistakable rods. Other bacteria, of many kinds, are constantly liable to be confounded on mere inspection; and the reaction to various dyes, the appearance of growths or cultures in test-tubes, and the symptoms produced in animals may be necessary before a definite name can be given to the species in question. Many species, also, vary somewhat under different conditions: the tubercle bacillus is not quite the same in shape if derived from a bovine animal as if from a human being. Not so the anthrax bacillus.

A Sensational Transformation. Madame Henri, however, subjected specimens of this bacillus to ultra-violet light, and transformed them, after merely twelve minutes' exposure, so that they became circular instead of elongated, and could only be called cocci—the general name for round bacteria. These cocci were no longer anthrax bacilli, and could in no way be mistaken for them. No one, now studying them for the first time, could in any respect connect them with anthrax bacilli, from which they were, in fact, directly descended. Injected into animals susceptible to anthrax, these cocci produced none of the symptoms of anthrax, but a novel set of symptoms, less severe, unlike those produced by any known microbes in those animals. The newspaper reports of this discovery were headed "A New Disease," but we have enough diseases already, and that is not the point at all. The value of the inoculation test lies in its demonstration that the anthrax bacilli had been really—that is, chemically—transformed, and not only altered in surface appearance. The fact is crucial. Further, this transformation is permanent. The cocci remained as cocci for months, under ordinary conditions of culture; and this period, in the case of bacteria, means an almost unthinkable number of generations. Yet the descendants were cocci, of a type hitherto unknown, when tested by their manner of growth in cultures, and by their chemical reactions in living bodies—because their vastly remote ancestors, countless generations before, had been exposed to ultra-violet light for twelve minutes.

Variations in the exposure, as regards time and intensity, produce various results. Too long an exposure to such light is fatal to all bacteria, we believe. Briefer exposure produced curious intermediate forms of bacteria, which were unstable, the cultures after a time losing their new character. But while there remain endless

opportunities for experiment, in the way of exposing all kinds of bacteria to a literally infinite variety of external influences, the main fact of the profound and permanent transmutation of a bacterial species, by external conditions, has been established.

The Significance of the Results. For a moment we must turn aside from our main inquiry to note the practical significance of these results. In general, the hygienist is still entitled to isolate infectious disease, and to recognise the way in which bacterial species are handed from one host to another, retaining their identity. The present practice of public health, on these lines, has overwhelmingly justified itself. But clearly there is more to learn, and many existing puzzles may be resolved. It is, for instance, a serious matter that a bacillus which closely resembles, but is not, that of diphtheria should frequently be found in the mouths of healthy persons. It is no less serious that a bacillus which is normally present in the bowel of every one of us should be very similar in many respects to the bacillus of typhoid or enteric fever. If the anthrax bacillus can be transformed into a coccus, which resembles it in no way whatever, resemblances such as those we have quoted must be looked upon in the most serious light.

But for us now it is the deeper biological issue that presses. The transformation of species has been proved in this instance. Organic evolution has been effected, in one case, in twelve minutes, and a new form of life has been brought into being. A bacterium certainly offers us the problem of the origin of variations in a very simple form. First, it consists of only one cell, which divides to form the next generation. The distinction between germ-plasm and body-plasm, between germ-cells and body or somatic cells, does not exist. If we can change the body of the bacterium, we also change its germ-plasm, for they are one and the same. But when we are dealing with any of the higher forms of life, even though we change the body by external conditions, we have yet to show that we have changed the germ-cells. If we have not, our experiment has no bearing on evolution; and it is certain that, in many instances, the change in the parental body involves no change in the germ-cells which it bears.

Bacteria Have No Sex. The second point is, if possible, even more important. Bacteria have no sex. Each individual is the offspring of a single parent. There is no ripening of "germ-cells," no casting out of certain parts of the nucleus, as in the maturation of the typical ovum or female germ-cell of the higher animals and plants. There is no crossing, no recombination of qualities or factors from two parents. There is no parting or bringing together of factors hitherto always united, or else long parted, but now united again, as in the Mendelian interpretation of reversion. In the case of the bacteria, we are studying something earlier and deeper than sex. But the whole of Mendelism, and the whole of the help it affords us in the study of organic evolution, depend upon the existence of sex in the first place. If there be only one parent involved, Mendelism cannot begin. If there be only one parent involved, Mendelism not merely has no idea how any variation could occur at all, but is inclined to deny its possibility.

Mendelism Fails to Explain Organic Evolution. Yet there was certainly a time when Life did not exhibit sex, and sex is therefore itself one of the products of evolution—sex and its consequences, such as Mendelism. Here is another reason, were more wanted, why Mendelism cannot begin to explain organic evolution. And it is a reason why experiment on asexual forms of life, such as bacteria, is of such transcendent importance in the present state of biological science. It is perfectly clear that, if we are to get any further in this matter, we must eliminate the complication of sex altogether—which means, of course, that we abandon Mendelism as a means of explaining organic evolution, invaluable though it will always be as an explanation of comparatively recent details in that process.

Of course, we cannot escape from sex in studying any but the simplest forms of life. But we now need to make experiments in which the complications due to sex are averted. We must take parents who are similar, instead of being dissimilar, as in Mendelian experiment; we must avail ourselves of Mendelism in order to be sure that the parents are really similar genetically, instead of being merely similar somatically; and then we must modify external conditions in order to see how the offspring are affected, if at all. The total and radical difference, in principle and in expectation, between such experiments and those of the Mendelians will be evident to the student. Yet both, it will be seen, are indispensable for progress; and it is a deplorable fact that experiments of this Lamarckian class, as we may conveniently call it, are at present being con ducted anywhere in the world except in Britain.

The Germ-Cells of the Body. When experiments of this kind were made in the past—their number being small and their quality poor—the observer had no clear ideas as to how the process he hoped to observe could work. The parental body was modified by Nature, and the body of the offspring might be similarly modified. Today the case is very different. Thanks above all to the great survivor from the nineteenth century, Professor Weismann, we have clear ideas as to what is involved in the hereditary process. We know that there are definite reproductive glands in the parental body, containing a cellular tissue of a unique order, and that from its cells are derived the ultimate bearers of heredity, which we call the germ-cells, or gametes. Any influence acting upon the parent must affect the gametes, or it cannot affect the heredity of the offspring. Crucial to our inquiry, therefore, is an exact understanding of the relations between the processes of the parental body and the gametes which it produces.

A leading student of this subject, Dr. F. A. Mjöen, of Christiania, has recently described the facts in the following words, which are true of the germ-cells in the animal kingdom generally,

though written with special reference to man. "The germ-cells are located in the human organism in such a way that the individual has a natural protection against racial poisons, and pecially those which, like alcohol, modern lustry provides by an elaborate process of nufacture. Surrounding the germ-cells of the dividual we find a sort of protecting membrane. o blood-vessels are in direct contact with permatozoon or ovum. When chemical poisons re brought into the animal body, they find their ay to all organs and all cells of the organism ith perhaps the only exception, the germ-cells. ature has in its wisdom arranged a special otection for the most sensitive stage of human e, the stage of conception. There is hardly y doubt that the above-mentioned protection pparatus acts against most of the poisons, but here are exceptions to the rule. Such exceptions re ether, chloroform, and the stronger alcohols. he proof that this is the case lies in the fact hat these bodies have been found in the germ-plasm by means of chemical analysis."

Immunity of the Germ-Plasm from Poisons. This relative isolation in the parental body is a general biological fact of profound importance, quite apart from the special question of the racial poisons. The germ-plasm is in a large degree independent of the vicissitudes and vagaries of the parental body. The parental blood may be charged with many unusual or even morbid agents, poisons taken with the food, poisons made by microbes invading the body, and so forth. But, of all the parental tissues, the germ-plasm is the most sheltered, since it is never in direct contact with the blood. It can well be imagined that if the germ-plasm, which carries the whole future of the species, were as liable to damage as the body of the transient individual, the race could not persist at all.

The reader will notice that the exceptions quoted by Dr. Mjöen all belong to one chemical class, and the fact is very important. It is probable that most colloid substances, in general, never reach the germ-plasm, whether for good or evil. They are unable to pierce the protective membrane, and therefore, though circulating freely in the blood, they no more affect the germ-plasm than if they were not present at all. Most of the poisons produced by microbes belong to this category; and hence is explained the surprising but highly necessary independence which the germ-plasm displays towards *nearly all* forms of parental infection. Ether, chloroform, and alcohol are typical of the substances, known to students of the nervous system, which have the power of penetrating into nerve-cells and paralysing them. Hence the familiar combination of these three substances in the anæsthetic which is accordingly called "A.C.E. mixture." The chemists point out that these substances have the power of dissolving the "lipoid," or fatty envelope, which surrounds and usually protects nerve-cells. Probably much the same obtains in the case of the germ-cells and their protective membrane. We see, therefore, how rash and unscientific it would be to assume, as many have assumed, that all influences affecting the parental body are bound to be reflected in the body of the offspring.

But doubtless the contrary dogma is still more absurd—the assertion that the germ-cells live in a universe of their own, totally untouched by all influences radiating from the universe we know. That, however, is—or perhaps we may say was—the neo-Darwinian position. It was based upon a very general forgetfulness of a crucial process which we must here recall. When Weismann and his followers taught the world to realise the separateness and distinctness of the "germ-plasm," and exploded the idea that all the tissues of the parent combine to form the corresponding tissues of the offspring, we all were inclined to overlook the fact that actual germ-cells are not things given, and pre-existing in the parental body, but are, in fact, being actively manufactured in it throughout the whole of the reproductive period. The process we have forgotten is called gametogenesis.

The Germ-Cell Vital in Organic Evolution. It is all very well to talk of the "germ-plasm" and the "germ-cells" as something fixed and immutable, but the facts are very different. The term *germ-cell* or *gamete* can be applied only to a "ripe" ovum, or to a spermatozoon. When we ask the history of these things, we find that they have by no means always existed, by a process of "preformation," in the parental body. The female organism prepares ripe ova at definite periods, and the process is an intensely active one. The male organism similarly prepares spermatozoa, by intensely active changes within the germ-plasm. These processes, which involve the genesis of gametes, are called gametogenesis; *and the crux of organic evolution lies here. Organic evolution depends upon variation. Variation results from novelties in germ-cells. Germ-cells are made by gametogenesis.* This is the heart of the whole problem. The Mendelian will teach us an infinite number of details as to the consequences of mating germ-cells, but he can deal only with what the germ-cells already contain. *It is in their making, not in their mating, that the real problem lies.* The central evolutionary fact called variation is not, as Professor Bateson has too enthusiastically said, the result of combinations or re-combinations of factors, but depends upon the making of factors by and in gametogenesis.

In earlier years Professor Bateson himself, before he was carried away by Mendelian specialism, expressed the real truth very forcibly when he said that "variation is a novel cell-division." The cell-divisions by which the gametes are made from the ancestral cells in the germinal tissues, and which we call gametogenesis, are the makers of evolution. The task now before biology is to discover the influences which affect that process.

Reproductive Tissues Examined. When we examine the reproductive tissues under the microscope we are impressed by their intense activity. The making of germ-cells is a business which requires oxygen, water, nutriment, like

all other vital processes. It is the parental body that supplies these necessities, without which the process ceases; and at once the neo-Darwinian notion of the impenetrable isolation of the germ-plasm breaks down. Though protected from direct contact with the blood, and all the hazards that may involve, the germ-plasm is yet, like the unborn child, nourished entirely by the parental blood. If germ-cells were preformed, and simply shed at intervals, as Weismann taught in his earlier writings, we should not expect the parental blood to affect them. But, in fact, they are made in the body by active processes of nutrition and metabolism, which entirely depend upon the parental blood to supply food, air, and water and to remove carbonic acid and the various waste products of metabolism. We may, indeed, assert that the active germ-plasm, during the reproductive period, bears to the body which houses it a relation closely similar to that between the mammalian embryo or fœtus and the maternal tissues. The theory of isolation is untenable, and we must, instead, prepare ourselves for decades or ages of inquiry into all the factors that affect the germ-plasm and gametogenesis, with consequences for the offspring, and thus for the evolutionary process.

External Conditions Affecting Germ-Plasm. In the foregoing paragraphs we have made an assumption which is generally accepted, but is quite unwarrantable. We have been arguing that the germ-plasm can be affected *only* by and through the body which houses it, and we have therefore been at pains to learn what chemical substances can pass into it from the somatic blood, and what cannot. The inquiry is vastly important, but there is another possibility which we have forgotten, and to which Madame Henri's experiments will recall us. She showed that certain cells—having the essential properties of germ-cells, in that new generations of the species were derived from them—could be modified by exposure to a certain form of light, with results which remained in subsequent generations. But the germ-plasm in the bodies of higher animals, though housed in those bodies, is not thereby cut off utterly from all direct influences, such as those which played upon Madame Henri's anthrax bacilli. In a word, we have omitted to consider the clear possibility that *external conditions may directly affect the germ-plasm*, quite apart from their influence upon the body of the parent.

The student is familiar with the celebrated phrase, never uttered nor written without deceiving somebody, which asserts that "acquired characters are not transmitted." That dogmatic denial is commonly quoted against the possibility that external conditions can ever affect the course of evolution. But in the instance before us we are not so much referring to "acquired characters," or even to the existence of the parental body at all! In that parental body is a special form of cell-producing tissue which we call the germ-plasm. May not external conditions affect that germ-plasm *directly*, as if the parental body were not there; as if that germ-plasm were a colony of bacteria exposed to ultra-violet light?

Effects of Temperature and Radiations. The leaders of experimental biology today are well aware of this possibility. It is never henceforth to be forgotten. For instance, the body of the individual is conveyed from a cold country to a hot one, or is experimentally enclosed in a chamber having a temperature very different from that to which the species is accustomed. This change of temperature may affect the individual body, and, in doing so, it may indirectly affect the germ-plasm which that body contains. But, in any case, the germ-plasm itself is being abnormally heated or cooled, no less than if Professor Carrel had contrived, as he could, and doubtless will, to excise the reproductive glands and keep them alive in isolation from the body to which they belonged. It is more than probable that the direct effects of so important an external condition as temperature, acting during the process of gametogenesis, which must be largely chemical, will affect that process, with consequences for the offspring, as it affects the simpler chemical reactions of every day.

So with radiations. Ultra-violet light has small penetration, and we cannot very well imagine that it could affect the germ-plasm in an ordinary mammal, or, at any rate, in the female, where the reproductive glands lie deep. But in many insects, for instance, the germ-plasm lies so near the surface that ordinary sunlight may affect it. Further, there are other forms of radiation which have far greater powers of penetration than ultra-violet light. The Röntgen rays belong to the same order as ultra-violet light, but have a shorter wave-length and correspondingly high penetration. Many living beings are more or less exposed to radiations of this order, and their germ-plasm may be affected accordingly, totally without reference to any action upon the body of the individual as a whole, or any so-called "inheritance of acquired characters."

Destruction of Germ-Plasm by Röntgen Rays. In this connection it may be added that the Röntgen rays, in their harder and more penetrating forms, have a profound effect upon the germ-plasm of mammals. The result best known is the practical destruction of the germ-plasm, with consequent sterility. Very serious results may follow, as is obvious, unless workers with the Röntgen rays take steps to protect themselves. The action is a selective one upon the germ-plasm. The rest of the body and its various glands are unaffected, so far as we know. No better illustration or proof could be offered to the student of the fact, fundamental of organic evolution, that the germ-plasm is not isolated from the universe, but is part of it, and may be *directly* modified by external agencies, without any part being played by the body of the individual at all. It is this study of the direct action of the environment upon the germ-plasm that evolutionists have most neglected hitherto, but that neglect is now being speedily remedied.

C. W. SALEEBY

Qualifications of a Secretary. The Different Kinds of Shares and Stocks. Transfers and Transmissions. Company Meetings.

THE SECRETARY OF A COMPANY

The duties of a secretary of a limited liability company are so important and responsible, and so many penalties are attached to breaches of the Companies Law, that it is of the greatest importance that a secretary should know just what his duties are. He is often referred to as the mouthpiece of the directors, and, while this may not be strictly accurate, it conveys a very good idea of what the secretary is. In some unimportant companies, it is true, the secretary is little more than a clerk, and is given instructions as to the many legal duties which in virtue of his office he must execute, but in other companies the secretary is the most important of all the officials. It is very often he who tells the directors what they must and must not do; and while nominally it is they who should instruct him, in many cases it is actually he who instructs them.

Duties of a Secretary. It may be well at the outset to give a brief summary of what the duties of a company secretary are. In the first place, it is on him that the responsibility lies to see that all the statutory requirements imposed by the Companies Acts are fulfilled. Then it is he who has to keep all the records of the company, and to see that the accountancy work is properly carried out and the balance-sheet prepared. And he has to attend all meetings of directors and shareholders, take minutes, or arrange for the taking of them, and keep a correct record of such meetings. He must also see that whatever is decided upon at such meetings is duly carried out. Of course, he has assistance in all these things, but the responsibility rests upon him.

Qualifying for the Post of Secretary. In order to fit himself for the carrying out of these important duties, a secretary needs to make a thorough study of company law and procedure. There are many admirable books published which set forth more or less fully all the duties of a secretary; and the Companies (Consolidation) Act, 1908, which can be bought for a small sum, should be read and understood, and its provisions remembered. The secretary is appointed to his office by the directors, and immediately he receives his appointment he should master the memorandum of association and the articles of the company. Then he must know thoroughly the workings and conditions of his own company, so that he can answer without delay or hesitation any questions his directors may ask him, and supply any information they may desire. At the same time, he must have his staff well in hand, and command the respect of all. No man who has not the instinct and ability for managing subordinates can possibly hope to succeed in the difficult post of secretary of a limited company.

Making a Return of Allotments. One of the first duties of the secretary of a company, if he has been appointed at its formation, is to make a return of allotments. This is done on a special form, and the particulars that have to be given have already been explained. The return must bear the signature of the secretary, and be stamped with a five-shilling stamp. When a return includes several allotments made on different dates, the dates of only the first and last of such allotments should be entered at the top of the page, and the registration must be effected within one month of the first of these dates.

The Register of Members. The register of members has also been referred to. This must be made out as soon as possible after the company is registered; and if a company fails to comply with this requirement it is liable to a fine not exceeding five pounds for every day during which the default continues; and every director and manager of the company (which includes the secretary) who knowingly and wilfully authorises or permits the default is liable to a like penalty. This register of members has to be kept at the registered offices of the company, and must during business hours (subject to such reasonable restrictions as the company in general meeting may impose, so that not less than two hours each day be allowed for inspection) be open to the inspection of any member gratis, and to the inspection of any other person on payment of one shilling, or such less sum as the company may prescribe for each inspection. Any member or other person who may require a copy of the register, or any part of it, must have it supplied, at a cost of sixpence for every hundred words. If any inspection or copy thus requested is refused, the company is liable for each refusal to a fine not exceeding two pounds, and to a further fine not exceeding two pounds for every day during which the refusal continues, and every director and manager who knowingly permits such refusal is liable to a similar fine. For convenience of bookkeeping a company may, on giving notice by advertisement in some newspaper circulating in the district in which the registered office of the company is situate, close the register of members for any time or times not exceeding in the aggregate thirty days in each year. The register will have to be amended from time to time owing to the deaths of shareholders, or the marriage of single women who hold shares, and so on. In making necessary alterations there must be no erasure, obsolete entries being ruled through. Any alterations

must be initialled by the person making them. A column for remarks should be provided,

The Share Certificates. The secretary as well as one or more of the directors will sign all share certificates, and a receipt acknowledging the safe arrival of his certificates should always be sought from a shareholder. The share certificates are exchanged, as already explained, for the banker's receipts or letters of allotment, and these, when they come from the shareholders, are cancelled by stamping the word "Cancelled" across their face, and are then filed and kept by the secretary of the company. If by any chance a shareholder shall have lost or mislaid his receipts, then he can have a share certificate on giving to the company a letter of indemnity, which protects them against any loss or damage should the receipts be found by an unauthorised person. These letters of indemnity must be stamped with a sixpenny stamp. When the secretary has the share certificates made out ready he advises the shareholders, enclosing a form which they can fill up and send with their receipts in exchange for the certificates.

Share Warrants. Sometimes a company is empowered by its articles to issue for fully paid up shares share warrants, instead of share certificates. These warrants are made out to bearer, and are transferable by simple delivery, the holder's name not appearing in the share register. The stamp duty payable on a warrant is thirty shillings per cent., and the warrant must be stamped before it is signed and sealed. The holder of a warrant cannot be a director of the company on account of which the warrant is issued, and he cannot attend and vote at a meeting, but he may at any time, on fulfilling certain formalities, surrender his warrant for registered share certificates. The secretary will prepare a printed form in which any applicant for a share warrant will have to give the necessary information for identification, etc., before the directors will grant the warrant. The warrant is signed by one or more directors and the secretary, and is sealed by the company's seal. If many warrants are issued it is wise to have a special register for them, separate from the ordinary register of members.

Making Calls. Very few companies insist upon the whole amount of the value of each share being paid up at once. The usual method is to divide the amount up into four or more sums, and to state in the prospectus when these will fall due. Thus it might be stated that the shares were a pound each, half-a-crown being payable on application, half-a-crown on allotment, five shillings one month after allotment, and a final ten shillings three months after that. Where the company does not need a great deal of capital with which to trade, the prospectus may not set forth any definite times when the calls will be due, and it is then at the option of the directors to make a call when they think it necessary. For this purpose a meeting of the directors must be held, when some such resolution as the following would be proposed, seconded, and carried: "That a call of two shillings and sixpence per share be and is hereby made on the 100,000 preference shares of the company, and that the same be paid to the company's bankers on or before July 15th, 1914."

Notice of Call. The secretary should already have prepared and got ready to send to each shareholder a notice of call. This is headed "Notice of Call." Then follows the name of the company and the statement: "First call of 2s. 6d. per share on the 100,000 preference shares of £1 each of the company, making 10s. per share paid up." Of course, for succeeding calls the word "second" or "third," as the case may be, is substituted for the word "first." The wording of the letter is usually like this: "Dear Sir or Madam,—I beg to inform you that the directors have this day resolved that a call of 2s. 6d. per share be made on the ordinary shares of the company, and I am directed to ask that you will pay to such-and-such a bank, on or before July 15th, 1914, the sum of £5 on the forty shares that are registered in your name. Please forward your share certificate with the banker's receipt, so that the amount of the call may be endorsed on the former." At the bottom of the call notice is a form of banker's receipt. Of course, if the share certificates have not yet been issued, then, instead of the last paragraph, there will appear a note requesting the shareholder to preserve his receipt, to be exchanged later with his other receipts for the certificate. As the call moneys come in they must, of course, be entered up in the register against the shareholder's name, and on account of the shares he holds. The secretary must be very careful, when sending out call notices, to see that no shareholders are overlooked. As in the case of certificates, so with call notices: it is wise to have different coloured sheets for the different kinds of shares.

Forfeited Shares. Sometimes a shareholder fails to pay a call on the day appointed for payment, in which case the directors may serve a notice on him requiring payment, together with any interest that may have accrued. This notice must name a further day, not less than foureen days after, as a date before which payment must be made, and it should state that in the event of non-payment, at or before the time appointed, the shares in respect of which the call was made are liable to be forfeited. If the requirements of this notice are not complied with, then the shares in question may be forfeited by a resolution of the directors; and any forfeited share may be sold or otherwise disposed of on such terms as the directors think fit. The person whose shares have been forfeited, of course, ceases to be a member of the company in respect of the forfeited shares, but, in the words of the Act, "shall notwithstanding remain liable to pay to the company all moneys which, at the date of forfeiture, were presently payable by him to the company in respect of the shares, but his liability shall cease if and when the company receive payment in full of the nominal amount of the shares." No member is entitled to vote at a general meeting unless all calls or other sums payable by him in respect of shares in the company have been paid.

Different Kinds of Shares. There are many different kinds of holdings in a limited liability company, all carrying special privileges or responsibilities, and it is essential that the secretary should thoroughly understand the nature of these. First of all, there are the shares proper, which may be ordinary, preference, cumulative preference, deferred, or founders'. Then there is stock, which may be ordinary, preference, guaranteed, or debenture. And, finally, there are debentures, which may be debentures issued on a simple promise to pay, or mortagage debentures.

Ordinary Shares. These form the main capital of most companies, and take rank after preference shares for purposes of dividend. If a company's shares were all ordinary, then the net profits, except for any amount set aside as reserve, would be divided among the shareholders at a uniform rate of so much per share.

Preference Shares. These are shares which receive a certain percentage of profit, usually 6 per cent., before any other shares receive a dividend at all. If the shares are preferential as to capital as well as in regard to dividend, then, in the event of a return of capital at a winding-up of the company, the holders of these shares would receive back their value before any other shareholders receive theirs.

Cumulative Preference Shares. In the case of cumulative preference shares, any unpaid dividends, owing to lack of profits in certain years, have to be carried forward, and their accumulated amount paid before the other shares receive any dividend at all.

Deferred Shares. Ordinary shares may be divided into preferred ordinary and deferred ordinary. The deferred do not receive any dividend until a certain specified and fixed rate has been paid to the preferred ordinary, but, when the deferred have received the rate of interest agreed upon, the preferred share with them the surplus.

Founders' Shares. These are also called management shares, and they only participate in the profits after all the other classes of shares have been paid fixed rates of dividend. In highly successful companies that make huge profits they are exceedingly valuable. As their name implies, they are usually issued to the founders or promoters of companies, and sometimes to the underwriters.

Stock. Where the articles of a company allow it, fully paid-up shares may be converted into stock, a certain amount of stock being given for an equivalent value of shares. Stock has this advantage over shares, that it may be bought and sold in fractional parts, whereas shares can be transferred only in multiples of the value of a single share. If the articles of association do not permit of the issue of stock, and it is considered desirable to issue it, the articles may, by special resolution, be altered to permit of the issue of stock.

Ordinary Stock. This bears the same relation to the other kinds of stock that ordinary shares bear to other kinds of shares. The dividend, therefore, varies with the prosperity or otherwise of the company. When the same kind of stock issued at different times in a company's history is amalgamated, it is called consolidated stock.

Preference Stock. This ranks for payment of dividend next to the guaranteed stock, which is described below. There may be various issues of preference stock, ranking one after another for dividend; thus, that of the year 1900 would rank before an issue of 1910, and so on.

Guaranteed Stock. This does not mean that the dividend or capital is guaranteed by some outside person, but that the agreed rate of dividend is guaranteed to be paid before any other class of stock except debenture stock receives anything.

Debenture Stock. This stock ranks first, and the agreed rate of dividend is usually lower than in other classes of stock, owing to the increased security.

Debentures. A debenture is a bond given by a company for money lent to it, in which it agrees to repay the loan at a future time, and meantime to pay a specified rate of interest. Sometimes the promise to repay a debenture is secured by a mortgage on the company's assets, and in such a case the security is vested in trustees, who hold it for the debenture holders. A debenture holder is thus not a shareholder, but a creditor of the company, and ranks for payment before all classes of shareholders. Sometimes debentures are perpetual and cannot be paid off, in which case they are called irredeemable debentures, as distinct from redeemable debentures.

The Transfer of Shares. When the shares in a limited liability company change hands, as for instance by a sale, a transfer has to be arranged and recorded in the company's books, and this work is under the direct supervision of the secretary. In small companies he carries out the routine himself, but in large companies, where there are constant transfers, a special department, with a registrar at the head, working under the secretary's direction, does the work. According to Table A of the Companies Act, 1908, the instrument of transfer of any share in a company must be executed by both the transferor and the transferee; that is, both must sign and seal it in the presence of witnesses. The transferor is deemed to remain the holder of a share or shares until the name of the transferee is entered in the register of members in respect of it. Shares in a company must be transferred in the following or some similar form, approved by the directors: "I, A.B., of so-and-so, in consideration of the sum of so much paid to me by C.D., of so-and-so (hereinafter called 'the said transferee'), do hereby transfer to the said transferee the share (or shares) numbered so-and-so, in the undertaking called the such-and-such Company, Limited, to hold unto the said transferee, his executors, administrators, and assigns, subject to the several conditions on which I held the same at the time

of the execution thereof; and I, the said transferee, do hereby agree to take the said share (or shares) subject to the conditions aforesaid. As witness our hands, this such-and-such a day of such-and-such a month, 1914."

The Option to Register. By the Act the directors may decline to register any transfer of shares, not being fully paid shares, to a person of whom they do not approve, and may also decline to register any transfer of shares on which the company has a lien. The directors may also suspend the registration of transfers during the fourteen days immediately preceeding the ordinary general meeting in each year. The directors may decline to recognise any instrument of transfer unless a fee not exceeding two shillings and sixpence is paid to the company in respect thereof, and the instrument of transfer is accompanied by the certificate of the shares to which it relates, and such other evidence as the directors may reasonably require to show the right of the transferor to make the transfer. The stamp duties for transfers are as follows: where the money consideration mentioned in the transfer does not exceed £5, sixpence; where it exceeds £5 but is not over £25, sixpence for every £5 or fraction thereof; where it exceeds £25 but is not over £50, five shillings; and afterwards at the rate of half-a-crown for every £25 or fractional part thereof up to £300. Beyond £300 the duty is at the rate of five shillings for every £50 or fractional part. Formerly, when a transfer of shares took place and there was no money consideration passing, a merely nominal consideration of five or ten shillings being stated on the transfer, the duty was a fixed sum of ten shillings. Now an *ad valorem* duty must be paid. But the Inland Revenue authorities allow the fixed duty of ten shillings when the transfer falls under any of the following headings: vesting property in trustees on the appointment of a new trustee or the retirement of an old one; a transfer for a nominal consideration to a mere nominee of the transferor, where no interest in the property passes; a transfer by way of security for a loan; or a re-transfer to the original transferor on repayment of a loan; a transfer to a residuary legatee of stock forming part of the residue divisible under a will; a transfer to a legatee for a specific legacy of stock; a transfer of stock being the property of a person dying intestate to the party entitled to it.

The Secretary's Duty in a Transfer. When he receives a form of transfer, the secretary of a company must see that it is properly executed and completed, and that the share certificate in respect of it has also been received, with the transfer fee of half-a-crown. It is then the practice in many companies, though no obligation rests on them to do so, for the secretary to write to the transferor, saying that the transfer deed has been received, and that, unless he hears to the contrary by return of post, he will be registering the transfer in the company's books. The secretary must see that the transfer is properly and adequately stamped, as in the event of this not being the case he is liable personally to a penalty of ten pounds. Every transfer must receive the sanction of the directors, and so the secretary will place any proposed transfers on the agenda for the next directors' meeting. Everything being all right, a resolution will be passed that the following transfers be and are approved, and that the necessary certificates be issued under the seal of the company. The transfers will be signed by the chairman of the meeting, and the necessary entries must then be made by the secretary in the register of transfers and in the register of members. The old certificates will be cancelled with a rubber-stamp impression across the face, and the new ones will then be made out. If by any chance the transferor has lost his certificate, the secretary will require a letter of indemnity before issuing a new certificate.

Transmission of Shares. When shares are transferred not by sale or gift, but by some legal process, as to a trustee in bankruptcy, to a legatee by will, or to a committee in lunacy, the operation is called a transmission. Before registering the transmission the directors must satisfy themselves as to the bankruptcy, death, or lunacy of the shareholder whose shares are being handled. In case of the death of a shareholder, the secretary will require the production of probate or letters of administration, and the names of the executors will be entered on the register of members.

The Company's Common Seal. On many documents, as already indicated, such for example as share certificates, there must be an impression of the common seal of the company. This is a very important matter, for according to the Act: "Any contract which if made between private persons would be by law required to be in writing, and if made according to English law to be under seal, may be made on behalf of the company in writing, under the common seal of the company, and may in the same manner be varied and discharged." It is really the official signature of the company, and it is usual for the directors to make special arrangements for its custody, so that no unauthorised impressions may be taken. Table A of the Companies Act (1908) enjoins that the seal of a company shall not be affixed to any instrument except by the authority of a resolution of the board of directors, and in the presence of at least two directors and of the secretary, or such other person as the directors may appoint for the purpose; and those two directors and secretary or other person aforesaid shall sign every instrument to which the seal of the company is so affixed in their presence. It is usual for the seal to be kept locked, so as to put it out of use, and to be placed in an iron safe in the office of the secretary. The chairman or managing director has one key, and the secretary another. Records of the occasions when the seal is used are often entered in a book kept for the purpose, which sets forth the date, the documents sealed, and the signatures of those present. By the way, the Act declares that "every limited company must have its name engraven in legible characters on its seal;" and if a seal is used in which this provision has not been carried out, any director, manager, or officer of the company,

or any person acting on its behalf, who uses or authorises the use of such a seal, and purporting it to be the seal of the company, is liable to a penalty of fifty pounds.

Company Meetings. A company's policy is fixed at the meetings of its directors and shareholders, and it is absolutely essential that the secretary should be thoroughly well up in the details of the procedure which has to be followed at these meetings.

The First Statutory Meeting. The Companies (Consolidation) Act, 1908 enjoins that every company shall, within a period of not less than one month, nor more than three months, from the date at which the company is entitled to begin business, hold a general meeting of the members of the company, which shall be called the statutory meeting. At least seven days before the day on which the meeting is held the directors must forward a report called "the statutory report" to every member of the company, which report must be certified by two directors, or, if there are not two, by the sole director. It must state the total number of shares allotted, distinguishing shares allotted as fully or partly paid up otherwise than in cash, and stating, in the case of shares partly paid up, the extent to which they are paid up, and in either case the consideration for which they have been allotted. It must also state the total amount of cash received by the company in respect of all the shares allotted, distinguished as indicated above; an abstract of the receipts of the company on account of its capital, whether from shares or debentures, and of the payments made thereon, up to a date within seven days of the date of the report, exhibiting under distinctive headings the receipts of the company from shares and debentures and other sources, the payments made thereout, and particulars concerning the balance remaining in hand, and an account or estimate of the preliminary expenses of the company. The report must also contain the names, addresses, and descriptions of the directors, auditors, managers, and secretary of the company; and the particulars of any contract the modification of which is to be submitted to the meeting for its approval, together with the particulars of the modification or proposed modification. The report must be certified as correct by the auditors of the company, and a certified copy must be filed with the Registrar of Companies directly the report has been sent to the members.

Procedure at the Meeting. Though the statutory meeting is more or less of a formality, a number of regulations must, according to the Act, be strictly carried out. The directors must, for instance, produce at the beginning of the meeting a list showing the names, descriptions, and addresses of the members, and the number of shares held by them respectively, and this list must be allowed to remain open and accessible to any member during the whole of the meeting. The members must be at liberty to discuss any matter relating to the formation of the company, or arising out of the report, whether previous notice has been given or not, but no resolution of which notice has not been given in accordance with the articles may be passed. The meeting may adjourn from time to time, and at any adjourned meeting any resolution of which notice has been given, either before or subsequently to the former meeting, may be passed, and the adjourned meeting has the same powers as an original meeting. Of course, the statutory report does not have to be filed in the case of a private company, but in the case of a public company if it is not filed, or the statutory meeting is not held, the company may be wound up by the Court, or the Court may order the meeting to be held and the report filed.

The Annual General Meeting. A general meeting of every company must be held at least once in every calendar year, and not less than fifteen months after the holding of the last preceding general meeting. It must be held at such time and place as may be prescribed by the company in general meeting, or, in default, at such time in the month following that in which the anniversary of the company's incorporation occurs. If not so held, the company and every director, and also the manager, secretary, and other officer of the company who is knowingly a party to the default, is liable to a fine not exceeding fifty pounds. If the general meeting is not held in accordance with this provision of the Act, any member may apply to the Court to call or direct the calling of a meeting. Seven days' clear notice, at least (exclusive of the day on which the notice is served, or deemed to be served, but inclusive of the day for which notice is given), specifying the place, the day, and the hour of meeting, and, in the case of special business, the general nature of that business, must be given to all such persons as are entitled to receive such notices; but the non-receipt of the notice by any member does not invalidate the proceedings at a general meeting. The notices are usually sent by post, and are considered properly served if they have been correctly addressed, stamped, and posted in the ordinary way.

The Agenda. The secretary will prepare an agenda, and it is usual to send a copy of it to the shareholders with the notice convening the meeting. The items would be something like this: (1) The secretary to read the notice convening the meeting; (2) letters of apology for absence; (3) minutes of the last annual general meeting; (4) report and accounts; (5) resolution approving and adopting accounts; (6) resolution that dividend of so much per cent., as recommended by the directors, be paid; (7) re-election of retiring directors; (8) re-election of auditors.

Of course, this agenda may be much elaborated. For instance, it may be arranged beforehand who is to propose and second the resolutions, and the names might be printed on the agenda. Most of the resolutions at any company meeting will be drawn up by the secretary, but if there is any difficult point it is always wise for him to consult the company's solicitor, so that the phraseology may insure that everything is perfectly in order.

Preparing for the General Meeting. The directors will instruct the secretary to prepare for the general meeting, but he should bring the matter to their notice by placing it upon the agenda at a directors' meeting some time before the time when notices have to be sent out. Having received formal instructions, he will prepare and send out the notices, with copies of the agenda, the report, and the accounts duly audited and signed by the directors and auditors, and the auditors' report. He will then prepare a more detailed agenda for the use of the chairman of the meeting, who should be the chairman of the company. A copy of this detailed agenda he will keep before him, as it will facilitate the taking of minutes. When the day of the meeting comes he will see that the room or hall where it is to be held is properly prepared with chairs, table, ink, pens, and so on. The chairman, directors, and secretary will sit at a table at the head of the room, and on the table will be the agenda-book, the minute-book, copies of the report and accounts, and the auditors' report, and always there should be a copy of the memorandum and articles of association in case it may be necessary to refer to them. The shareholders should be admitted to the room some time before the hour for beginning the meeting, and a record should be kept of their names as they come in. One method is to admit by special cards, when the cards collected form a record of the attendances; while another method is to let one or two clerks sit at a table near the door, and take the names as the members enter.

A meeting should begin at the scheduled time, the chairman and all the directors, with the secretary, being in their places before the appointed hour, so that there may be no delay. According to Table A, three members form a quorum; and if within half an hour from the time appointed for the meeting a quorum is not present, the meeting must stand adjourned to the same day in the next week, at the same time and place. And if at the adjourned meeting a quorum is not present within half an hour of the time appointed, the members present are considered as forming a quorum.

Proceedings at the Meeting. A quorum being present, the chairman calls on the secretary to read the notice convening the meeting, and any correspondence; and the agenda such as has been outlined is then proceeded with. The minutes of the last meeting, and the report, with the accounts, are usually taken as read, the meeting signifying its approval of this course by calling "Ay" or "Agreed." The chairman then moves the adoption of the report and the accounts, and the person who is to second is called upon to do so. The shareholders then have an opportunity of asking questions or criticising, and the resolution is put to the meeting. According to Table A, a resolution shall be decided on a show of hands, but the more common method is for the chairman to ask those in favour to say Ay and those against No, and if the Ayes preponderate he will exclaim "Carried."

Taking a Poll. Before or on the declaration of the result of the show of hands, a poll may be demanded by at least three members, and this may be taken at once, scrutineers being appointed by the meeting, or it may be taken "as the chairman directs." On a show of hands, every member present has one vote, but on a poll every member has one vote for each share of which he is the holder. No member whose calls are not paid up can vote. On a poll, votes may be given either personally or by proxy, and the instrument appointing a proxy must be in writing under the hand of the appointer or of his attorney. No person may act as a proxy unless he is entitled on his own behalf to be present and vote at the meeting, or has been appointed to act as proxy to a corporation. The instrument appointing a proxy must be deposited at the office of the company not less than forty-eight hours before the time for holding the meeting. The stamp duty on a proxy for use at one meeting or at an adjournment of it is one penny; but for use at more than one meeting, ten shillings. It is the responsibility of the secretary to see that all proxies are in order and properly stamped, as any irregularity invalidates them. At every meeting the secretary should have ready a list of proxies, with the votes represented by them, and he should also have the share register with him, in case of a poll being demanded.

The chairman may, with the consent of the meeting, and must, if so directed by the meeting, adjourn it from time to time and place to place, but no business may be transacted at any adjourned meeting other than the business left unfinished at the original meeting. When a meeting is adjourned for ten days or more, notice must be given to the members, as in the case of the original meeting.

Taking the Minutes. The secretary must be careful to have correct minutes of the meeting. Where the business is merely routine according to the agenda, this will be a simple matter, and the record should be written up directly after the meeting, while the details are fresh in mind. A draft should be made out and approved by the chairman, and then copied into the minute-book and signed by him as soon as possible, as until then they are not regarded as evidence of the proceedings.

Where there has been a great deal of discussion at a meeting, with proposal and counter-proposal, the secretary must exercise his discretion as to how much he will record. All the essential points must, of course, be entered, but in addition it is often wise to keep a record of some of the proposals that did not find a seconder even. Separate minute-books must, of course, be kept for the meetings of shareholders and the meetings of directors. In addition to the minutes, the secretary must also make a careful note of any instructions given at the meeting, and see that they are carried out promptly and accurately. The payment of the dividend is an instance in point.

CHARLES RAY

The Magnetic Needle. The Mariner's Compass. The Range of Magnetism. Effect of Physical Conditions on Magnetism. The Error of the Compass.

THE MYSTERY OF MAGNETISM

We must now conclude with a systematic if brief discussion of a subject to which reference has frequently been made in preceding pages. We had no choice but to consider the relations of light, magnetism, and the electromagnetic theory of light before we had properly defined certain of the terms which we employed. But, at any rate, these references to the subject must have interested the reader in it. It is the old story: *electricity*—which derives its name merely from the Greek word for amber—was once a sort of freak phenomenon, but now its study dominates the whole of the natural sciences; and, similarly, *magnetism* is derived from the Greek name for a particular ore of iron, but is now recognised to be a phenomenon of the widest possible practical and theoretical interest.

The Invention of the Compass. The ancients knew that the *lodestone* is capable of attracting iron, in whatever form, and of endowing such iron with a measure of its own properties. They also knew that other metals do not share in this property, and that the intervention of other metals between the magnet and the iron does not interfere with the attraction. But to the few facts they knew they added a vast amount of pure fiction, which was accepted as fact for many centuries. It was the invention of the compass that marked the first epoch in the science of magnetism. It is commonly believed that to the Chinese must be ascribed the first invention of this wonderful little instrument. It is stated by the Chinese historians that in the twenty-seventh century before Christ the compass was used in war. It is also a Chinese dictionary that first defines the lodestone. The Chinese appear to have long used the compass upon land before it was employed in navigation. It seems quite possible that the Chinese communicated their knowledge to the Arabs, and that the Arabs introduced it into Europe. At any rate, even in the twelfth century European sailors employed a primitive form of compass, which "seems to have consisted simply of an iron needle which was touched with the lodestone and placed upon a pivot or floated on water, so that it could turn more or less freely. It was found that such a needle came to rest in a position pointing approximately north and south. . . . As these compasses were made of iron (steel was not used till much later), and were probably ill pivoted, they must have been very inaccurate; and the difficulty of using them must have been much increased by the want of a card, which was a later addition, made apparently by the Dutch."

Discoverer of the Earth's Magnetism. The next stage in the history of our knowledge of magnetism is undoubtedly represented by the life-work of Dr. William Gilbert, of Colchester, who was physician to Queen Elizabeth, but who will be remembered not as a physician, but as "the Galileo of magnetism." It is true that he was President of the Royal College of Physicians and achieved great professional success, but he added nothing to medical science. On the other hand, he published, in the year 1600, the greatest work that has ever been written upon magnetism. He died three years later, at the (probable) age of 63. Gilbert was the absolute pioneer in this subject. Not only did he make many experiments, but we owe also to him the capital discovery of the magnetism of the earth. Having found that the whole earth is none other than a great magnet, Gilbert was thereby enabled to explain not only the direction occupied by the compass needle, but also what is known as the *magnetic dip*.

The Axis of a Magnet. We are apt to think of a magnet as a thing with two ends, but it is well to follow the example of Gilbert himself, and take the case of a spherical magnet, which also has "poles." The phenomena of magnetism do not at all depend upon the form of the magnet. We shall afterwards see that they are not *molar*, but *molecular*. Such a spherical magnet, then, like any other, has an axis and poles. That end of the axis which always turns northwards we usually know as the north pole, and conversely. We shall soon see that it would be much more correct to describe the northward-turning pole of the magnet as its south pole and the southward turning pole as its north pole. At any rate, when the magnet comes to rest, the vertical plane in which its axis lies is known as the *magnetic meridian*, indicating respectively the magnetic north and the magnetic south.

The Magnetic Needle. Having disposed of the notion that the molar form of a body has anything to do with its magnetism, we may now study the more common form of artificial magnet, usually called the *magnetic needle.* This will consist of a thin piece of hard-tempered steel which has been magnetised in one way or another. It may have been rubbed with a piece of lodestone or with an artificial magnet, or it may have been made magnetic by electrical means. A steel knitting-needle can easily be magnetised by the first process. First of all we must have some means of distinguishing one end from the other. Let us decide that the end we shall call A is to become the north pole of the magnet, and the other end, B, the south pole. Let us then take a magnet, place its north pole on the point A of the knitting-needle, and draw it along the needle from A to B. Similarly, we may draw the south pole of the magnet along the needle from B to A. If this

process be repeated often enough, we shall find that the knitting-needle has become magnetic. Such a magnetic needle may be made to float upon the surface of water, not because it is magnetic, but because of the surface tension of the water, as the reader will doubtless remember. And we find, when we lower it very gently upon the surface of water, that it will slowly turn until it comes to lie in the magnetic meridian. It is of the utmost value in many experiments to have a needle thus balanced so that it can move freely in a horizontal plane. A method employed by Gilbert, besides the method we have just described, was to suspend a very fine magnetic needle from a single fibre of silk, which scarcely interfered at all with its movements.

The Magnet and the Poles. What is known as the magnetic dip was independently discovered by several observers before the time of Gilbert. In 1544, a German vicar discovered that the magnetic needle, as he says, points downwards. "This may be proved as follows: I make a needle a finger long which stands horizontally on a pointed pivot so that it nowhere inclines towards the earth, but stands horizontal on both sides. But as soon as I stroke one of the ends with the lodestone, it matters not which end it be, then the needle no longer stands horizontal, but points downwards."

The magnetic dip varies in different places. It does not exist at all along a line which corresponds more or less with, but along a line which definitely differs from, the equator of the earth; this line is known as the *magnetic equator*. North of it the north end of the needle dips below the horizon; south of it the south end dips below the horizon. In each hemisphere, north and south, there is a point where one end or other of the needle dips vertically downwards. These points are known as the *north* and *south* magnetic poles of the earth respectively; but a further study of them belongs to the subject of terrestrial magnetism, and here we are dealing with the whole subject historically.

The magnetic dip having been discovered just before the time of Gilbert, it remained for him to explain it in terms of terrestrial magnetism. Before him there had been made, but not explicitly stated, the notable discovery of the mutual behaviour of the poles of magnets. This behaviour may be expressed by the very simple rule that *like magnetic poles repel, unlike magnetic poles attract each other*. The law of the intensity of this magnetic attraction and repulsion is the law with which we are already so familiar—it varies inversely as the square of the distance.

Para-Magnetic and Dia-Magnetic Bodies. Faraday studied an enormous number of bodies, and divided them into two great groups. Those which behave like iron, being attracted by magnets, he calls *para-magnetic*, while those which are repelled in greater or less degree by magnets he calls *dia-magnetic*. We need not give the list of substances which he tested. The interesting fact to notice is that almost every kind, if not absolutely every kind, of substance that can be experimented with is acted upon by a sufficiently powerful magnet in one way or another. We may select the following substances from Faraday's list of dia-magnetic bodies in order to show their heterogeneous character: Rock crystal, nitrate of lead, citric acid, water, alcohol, nitric acid, alkaline salts, glass, iodine, resin, sealing-wax, jet, sugar, wood, leather, beef, and blood.

The Range of Magnetism. Magnetic properties are not confined to solids. For Faraday found that gases have magnetic properties, though it is not necessary here to quote the table of his results. The most magnetic of all gases is apparently oxygen, though it may possibly be surpassed in this respect by its own modification, ozone.

Within the limits of magnetic action, the interposition of material bodies is of no more moment as such than it is in the case of gravitation, provided that the intervening bodies be themselves non-magnetic. It has already been noted that this important fact was recognised some centuries ago.

Though various forms of iron, for instance, are capable of magnetisation, they vary very much, and at present very mysteriously, in their behaviour when so magnetised. A piece of soft iron will become a magnet when it is touched by or placed sufficiently near to another magnet, but, so soon as it is removed from this influence, its magnetic powers vanish. Steel, however, or a hard enough iron, when adequately magnetised, will retain the property indefinitely.

How Physical Conditions Affect Magnetism. Certain illustrations of the effect of physical conditions upon magnetism may be quoted. Thus, in the case of soft annealed iron, under certain conditions a considerable percentage of induced magnetism can be retained. But the mere effect of a tap is sufficient to destroy this. This single instance is extremely suggestive.

Then, again, we may take the influence of temperature, which is found to be very decided. Up to a certain point a rise in temperature in the case of soft iron greatly increases its response to magnetism. Yet a point is reached beyond which the reverse action occurs, and the magnetism of the iron disappears. It is indeed true for all specimens and all varieties of iron or steel that there is a temperature—varying, of course, in different cases—which we may call the *critical* temperature, and beyond which the magnetism entirely disappears.

Molecular Theory of Magnetism. We commonly think of a magnetic needle as having two ends, which we distinguish as its north and south poles, but this is only a relation; and the remarkable fact which we discover when we break up such a needle is that this relation holds good of all its parts. Break the needle in two, and each half becomes a magnet, with its own north and south poles, their positions corresponding to those of the unbroken needle. Break up these halves again, and the same result is found. Must we not, then, conclude that the ultimate molecular units—not, of course, the ultimate units—of such a magnet are themselves

magnetised? In short, must we not form some *molecular theory of magnetism?*

Weber's Explanation. The theory of molecular magnets—that is, that the individual molecules of iron or steel are themselves magnets—was explained by Weber, who supposed that in unmagnetised iron the molecules are lying in all directions indifferently, and that they therefore neutralise each other's action, with the result that the mass, as a whole, has no magnetic action. Then, when the iron is magnetised, we may suppose that the molecules have all been turned more or less in one direction, so that their action is summated instead of being mutually neutralised. Such a theory evidently leads to the conclusion, which is verified, that there is a definite limit to the possible magnetisation of any body.

The Earth, the Sun, and the Magnetic Needle. In our brief introductory history of this subject we have already outlined one or two of the facts of terrestrial magnetism. We have seen that William Gilbert explained the behaviour of the magnetic needle by the extremely bold but justified speculation that the earth itself is a huge spherical magnet. It was this theory which led Gilbert to experiment with little, spherical models of the earth, which he called terrellæ, or *little earths.* We have also noticed the existence of the magnetic poles of the earth, and may briefly note that the term *isoclinic lines* describes lines drawn on charts of the earth so as to pass through places where the angle of dip is the same. At the magnetic poles the angle, of course, is 90 degrees. Again, though we speak of the needle pointing north and south, we must remember that, except along two lines, there is a *declination*, or variation, at every point upon the earth's surface between the true meridian and the magnetic meridian. "Isogonic lines" indicate places where the declination is the same.

Poets are apt to use the magnetic needle as a symbol of constancy—"true as the needle to the Pole." But, as a matter of fact, there are incessant changes in the behaviour of the needle at any given place as regards both *variation* and *dip.* Some of these can scarcely be measured in less than centuries, others definitely correspond to the year, and others, again, may be measured from hour to hour. Lastly, we may note the amazing fact that the behaviour of magnetic needles on the earth is influenced by the state of the sun. It is definitely known that sun-spots affect the magnetic needle.

The Error of the Compass. If the earth be a magnet, then it should have all the properties of a magnet. For instance, it should be capable of inducing magnetism in susceptible substances in its neighbourhood. It has this property, and it is found that steel masts and columns, pokers, hammers, and other objects of steel, are sufficiently magnetised to affect a compass appreciably. This is the result of induction by means of the magnet we call the earth.

This is a phrase used by Lord Kelvin in order to describe the influence upon a ship's compass of the ship's own magnetism. All the soft iron of a ship is magnetised by the earth's induction, though this magnetism is only temporary and not important. On the other hand, all the steel of the ship and its hard iron acquire a more or less permanent magnetism, the exact nature of which depends upon various factors, such as the position in which the ship lay while it was being built. This permanent magnetism of the ship is a very serious matter, and may mean the difference between life and death for the sailor.

The Greatest Inventor in History. It is not necessary here to describe the various kinds of error which the permanent magnetism of the ship may induce in the indications of the compass. But we must celebrate once more the great name of Lord Kelvin, that mighty genius whose practical inventions alone constitute him, perhaps, the greatest inventor in history, while his contributions to pure science would suffice to immortalise a dozen men.

The Thomson or Kelvin compass is now to be found on every ship that sails the seas, and no one can say how many lives it has saved or what worth of cargo. Among the distinguishing properties of the instrument we may briefly note the fact that the Kelvin compass contains six or eight magnetised needles instead of one, and that the various kinds of errors of the compass are corrected by means of appropriate apparatus, such as bar magnets, horizontal and vertical, the position of which can be altered, and balls of soft iron, which are fixed on to the binnacle at the level of the card of the compass, and which neutralise the magnetism induced by the earth in the soft iron of the ship.

The Field of a Magnet. We have already seen that in the neighbourhood of a magnet there is some essential difference from the conditions which prevail farther away. The area over which the magnet exercises its influence we may describe as the *field* of the magnet. We have already noted facts from which we may properly infer that the earth itself, being a magnet, has a field in its immediate neighbourhood. And this is so. The existence and some of the characters of a magnetic field may be shown by spreading some iron filings evenly upon a sheet of paper underneath which lies a magnet. If we tap the paper we find that these filings arrange themselves along a series of curved lines passing between the two poles of the magnet. These curved lines are known as *lines of force*, and their study is extremely complicated and interesting. The appropriateness of the name will be seen if we make a further experiment, which consists in lowering a small magnetised needle over the paper and seeing what happens to it. Its point will be found to follow one of the lines of force already indicated by the position of the iron filings, and if the north pole of the needle be downwards it will be driven towards the south pole of the magnet.

For further information regarding magnetism and its relation to electricity the student is referred to the chapter on Electromagnets on page 492. C. W. SALEEBY

Various Classes of Brickwork. Brickwork for Other Trades. Dealing with Old Brickwork. Underpinning in Brickwork. Brick and Tile Paving.

BRICK AND TILE WORK

Air Flues. Flues for conveying air into or out of a building in connection with its ventilation are often required. These may vary from large air ducts, in the case of the main flue of a large building, to a small flue formed in the thickness of a wall. The large duct is formed with brick sides and very frequently with a concrete floor and ceiling, and the walls may, if necessary, be plastered. Smaller flues are often formed in the thickness of the wall in the case of inlets, and should be formed without sharp bends or angles where possible, and should, if possible, be rendered [115]. Extract flues are sometimes carried up in the same stacks as chimney-flues ; in other cases several are gathered into horizontal ducts and thence taken to a vertical flue or upcast shaft, resembling a small factory chimney, which is usually fitted with some mechanical appliance for extracting the air. [See Ventilation.]

Forming Chases in Brickwork. It is often necessary to form a vertical recess in the face of a brick wall, to receive a rain-water pipe on the outer face, or one or more lead or iron water pipes internally. Where such chases are required it is desirable, when possible, to form them in building the wall, both the depth and width of the recess being the multiple of half a brick ; but, especially in the case of internal pipes, it is not always possible to foresee where they will be required, and chases must then be cut ; strong chisels are required, and the bricks are cut by driving the chisel into the brick and levering out the brick required to be removed. It is undesirable to cut brickwork that is newly erected, or, as it is termed, *green*, for this is liable to shake the wall and disturb the brickwork all round.

Chases may be formed for the most part wherever they are required ; but a chase may not be cut in a party-wall so that the back of it comes within 4 in. of the centre of the wall, and they should not be cut close to the angle where two walls are joined. A chase that has been cut in this way will always be somewhat rough on the cut surfaces, but may be rendered, if required, to have a smooth surface.

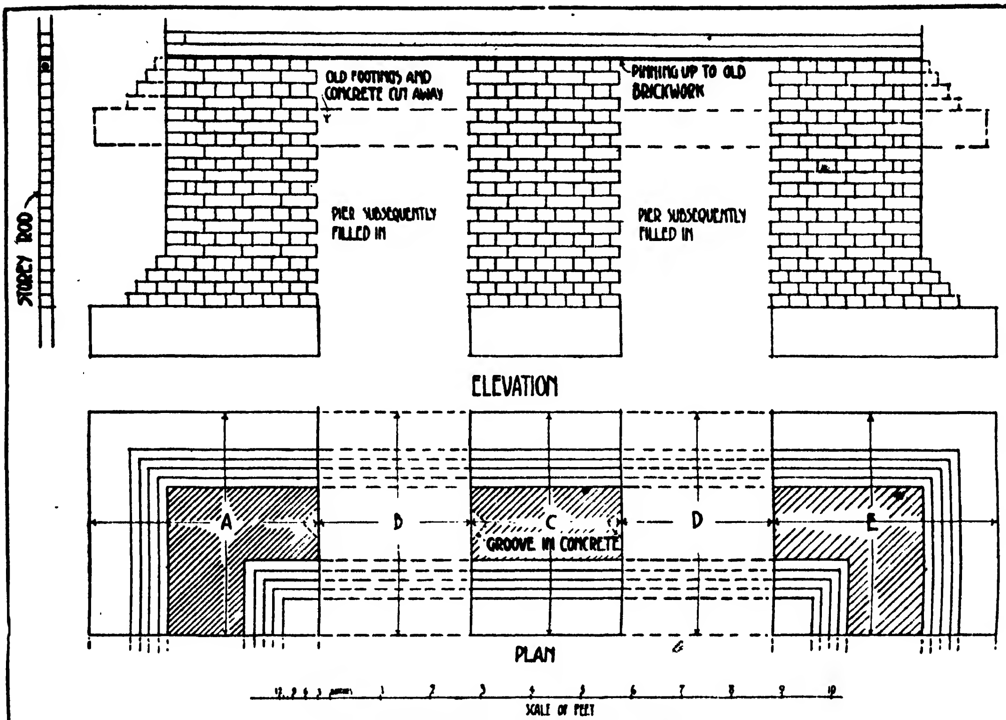
Perforations in Brickwork. Perforations are also required for many purposes in brick walls, as, for example, where the pipe from a w.c. or sink has to be passed through the wall from the interior to the outside. Such perforations are cut with chisels similar but of greater length, where thick walls have to be dealt with. Where the brickwork is old and of good quality the process may be very laborious ; the perforation is made larger than the size of the pipe, and the opening is made good with new brickwork after the pipe is in position.

Building-in and Pinning-in Stones. Very frequently it is necessary to insert in brick walls blocks of stone, which form the sills of window openings or the steps or thresholds of door openings. These may either be *built-in* as the wall proceeds, if they are prepared, or may be afterwards *cut and pinned-in*. In the first case the stone is placed in position when the wall has been carried to the proper height to receive it, and a bed of mortar is placed under each end, but it is usual to leave the centre of the stone without any mortar bed. This is termed *hollow bedding*, and the object is to permit the stone more freedom of movement if a slight settlement in the wall should take place, which may often prevent a fracture. When the brickwork is pointed down, on completing the work, all such hollow beds must be carefully filled with mortar, which is worked well into the back of the bed with the trowel. After the block of stone is bedded the building of the wall is continued, the brickwork being cut and fitted round the two ends of the stone.

Where a stone has to be cut and pinned-in the brickwork is cut away as far as is necessary to receive the ends of the stone, which is placed in position on a prepared mortar bed, and the brickwork is made good all round the stone, the cement mortar being forced in between the upper surface of the stone and the brickwork above ; where the brickwork has had time to settle thoroughly before the stone is pinned in, hollow bedding need not be resorted to.

Forming Sand Courses. In the case of stone staircases in which the ends of the steps have to be built into brick walls, and where the steps cannot be built in, it is usual to bed the bricks forming these portions of the wall that will be required to be taken out to receive the end of each step in sand instead of mortar. This allows the wall to be carried up above the sand courses, but permits of the bricks so laid being withdrawn without shaking the wall. It is, of course, essential that the position of all steps to be provided for in this way should be accurately set out, and the steps when inserted are pinned-in in cement mortar, and the brickwork made good round them.

Building-in Iron and Timber. The ends of iron bars are sometimes cut and pinned into brickwork, but this does not give a very good fixing, and, where possible, it is better to let the ends of such bars into blocks of stone built into the wall. This course is usually adopted in all cases in which a considerable strain is placed



114. UNDERPINNING IN BRICKWORK

upon the ironwork, as in the case of the hooks for hanging large gates.

The ends of timbers should not be built into brick walls, as they are apt to decay, but there should be formed, to receive the ends of all such timbers, a recess which will allow a free circulation of air round them.

Preparations for Fixing Joinery. Wherever joinery is required to be fixed, in brick openings or against the face of brick walls, preparation for its proper fixing must be made. A method formerly in vogue, but much less used now, was to build in at intervals wood blocks the size of an ordinary brick; but it was found that such blocks are apt to shrink, become loose, and therefore be unreliable, and in place of them similar bricks made of fine breeze concrete are now used. These are not liable to shrink, and give excellent fixing for nails and screws, but care must be taken if two adjoining faces are exposed giving a salient angle, not to split the brick in driving in nails. Another method is to build-in wood slips. These are thin layers of wood the same size as a brick, about ⅜ in. thick, and are inserted between two bricks in place of a mortar bed. Being thin, they are not liable to shrink appreciably, and are firmly held by the weight above them; but care is required in fixing joinery to them not to split them. Another method which answers admirably for fixing solid frames is to build into the brickwork iron *holdfasts*, one end split and turned up and down, or else split and spread outwards, the other end bent down and tapped for a screw [116]; this end is left exposed in the face of the brickwork, the frame is fixed by means of a screw to it, and the head of the screw may be counter-sunk. [See Joiner.]

Position of Fixing Blocks. Whatever the means of fixing adopted, points for fixing should be provided in all openings within 12 in. of the top and bottom, and at intermediate points not more than 18 in. apart, and in the case of dadoes, rails, etc., not more than 3 ft. apart horizontally, or more than 18 in. vertically. Where joinery is to be fixed to an old wall the bricklayer must cut a series of holes at similar intervals, into which the joiner drives wedges of hard wood, which are cut off flush with the face of the wall or of the plaster.

Bricklayers' Work for Other Trades. The bricklayer usually beds all wood plates and lintols supplied by the carpenter—*i.e.*, he lays on the surface of the brickwork which is to receive the plate an even bed of mortar on which the plate is laid and levelled. He also beds or builds-in templates, corbels, or brackets of stone supplied by the mason, or of iron supplied by the smith. He also beds door and window frames, and points all round them between the frame and brick reveals in cement; sometimes screeds are formed against the back of the reveals to receive the face of the joinery to be fixed, and this is usually done in mortar formed of one part of lime to three of sand, with the addition of 1 lb. of clean bullock's hair to every 2 cub. ft. of lime, to give it cohesion, as in plasterers' work. [See Plasterer.]

Altering Old Brickwork. The method of toothing new work to old has been already described [page 2727]. Another operation that is frequently necessary is the cutting of a new opening in an old wall. If the brickwork be sound in character, and the opening of moderate size, say 5 ft. or less, the opening may be cut away without any fear of collapse or settlement. An arch, with or without a lintol, is thrown across the opening as for a new arch, and the brickwork above made good to it; the jambs are also, in many cases, rebuilt, or at least refaced. If the work is not sound in character, special care must be exercised, as the cutting away is apt to shake the wall. When possible, a portion of the thickness only, say one-half, should be cut away, the new arch or lintol inserted under this portion, and the whole made good before the other portion is dealt with. If the opening is a wide one, and a girder or bressummer is to be inserted to carry the upper part of the old brickwork, the upper part of the wall is first carried on needles [see page 1410], the brickwork is cut away as required to form the opening, and the new girder is then put into position and supported on iron stanchions or storey posts, or by brick piers erected by the bricklayer. When in position, the upper flange is covered with a thick layer of cement mortar, on which slabs of stone are bedded, equal in width to the thickness of the wall above. On these stones a brick wall is commenced as already described, and is built up to the underside of the old brickwork, but no footings are necessary; the work is carefully set out and finished, so that it will support the under side of the old walling, tiles or slates bedded in cement being employed to make up any height that will not accommodate a full brick course. All such work is executed in cement mortar, and the process of finishing the new work tight up under the old, which involves a process of carefully filling in the last joint with mortar from the face of the wall, is termed *pinning-up*.

Underpinning in Brickwork. In underpinning an existing wall in brickwork, the process is, in some respects, similar to the last. A short description of the general process and particulars of the excavator's work was given on page 882. The illustration [114] shows an end wall of a building the foundations of which are to be carried down to a depth 5 ft. below their former level. The necessity for this may be due to a failure of the earth below the old concrete, or to provide increased height for a basement. In the first case the old wall will have shown signs of failure, and will have to be shored before the foundations are touched; in the latter case, if the ground be solid in character, the work may be executed without this preliminary in many cases; but judgment and experience alone can determine in any particular case which course to pursue.

The pier A or the piers A and E would, in most cases, be first dealt with. An excavation large enough exactly to receive the new concrete block is made to the necessary depth, and the sides are well timbered [page 877], and the concrete bed inserted, and allowed to set.

The bricklayer, after the new concrete foundation of the first pier or set of piers is in position, sets out the new footings on the top of it, with due regard to the position of the old brick walling to be supported, and erects his wall. This is built of the same length as the concrete foundations, and in erecting it a toothing is formed at the end to receive the intermediate lengths; at the top the wall is pinned up tight against the old one. In constructing other lengths of the wall subsequently, such as the angle pier E, if not carried out at the same time, and the central pier C, care must be taken to preserve the proper horizontal alignment of the different courses, so that when the intermediate portions, B and D, of the wall are built, the whole will bond properly, and form in effect, when completed, a homogeneous wall, properly bonded, and with regular and horizontal courses, and to ensure this, a *storey-rod* [114], consisting of a strip of board in which the courses are marked, should be employed, especially if the underpinning be of considerable depth.

Brick Paving. Brick paving [117] is used in various forms. Ordinary stock or other forms of brick may be employed, and laid flat or on edge, and are used for paving coal-cellars and similar positions where there is not much or heavy traffic; they may also be used around the outside of the building to form channels, which are sometimes employed to help in keeping the building dry, and for yards when the traffic is not heavy. In other positions subject to much wear and tear, as in the case of coach-houses and stableyards, *clinkers* [page 2456] are much used for paving. Staffordshire blue bricks of special form [118] are also frequently employed, their edges being chamfered to give a reliable foothold for the horses. Some form of hard bed should be provided to receive this paving. It may consist of hard dry rubbish, well rammed or consolidated with a heavy roller; but wherever hard bricks are used, and a thoroughly reliable floor is required, without any liability to become uneven with wear, a good bed of cement concrete at least 6 in. thick should be provided, and the ground below it should be previously well rammed or consolidated.

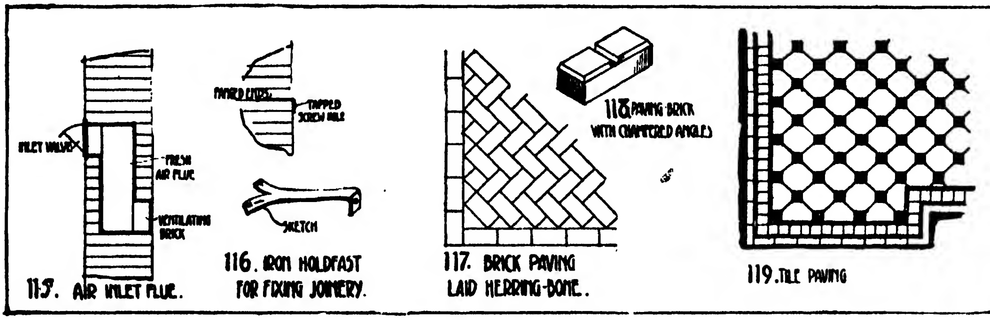
Laying Pavings to Falls. The floor of any uncovered yard must not be laid perfectly horizontal, or water would lodge on it and not run away, but the surface should be inclined, so that any water will run off to one or more convenient points, where it may be carried off by a drain. This fall should be formed in the concrete bed. This work is described as *laying the concrete to falls*, and requires careful setting out and levelling to ensure that the paving shall at no part be hollow, thereby retaining pools of water. The concrete is usually finished with a floated face in Portland cement and sand, to give an even bed for the bricks. These are bedded in cement mortar; the vertical joints may be filled with mortar as the bricks are laid, or may be kept fine, and when the floor is laid, either dry cement is brushed into the joints, or grout, consisting of cement and sand mixed with an excess of water, is brushed over the floor so as to

fill up the vertical joints. In laying brick floors, whether the bricks be laid flat or on edge, they may be laid in plain parallel rows, or in diagonal rows, or in the form known as *herringbone* [117]. If laid diagonally or herringbone, a plain border of straight bricks is usually formed, which may, if desired, be of a different colour to the other bricks. The best and most even surface of the brick should be exposed, and if it has a frog, this must, of course, be laid face downwards; it is also necessary, to produce good work, that bricks should be selected for uniformity in length, especially in herringbone work, otherwise much difficulty will be experienced in securing a uniform appearance.

Other Forms of Paving. Besides brick paving, various other materials are in general use; in almost all cases, a good bed of concrete is required as a preparation for the finishing surface, and as a rule this is finished with a floated face. rubbed down with large rubbers worked by hand, and polished. *Terrazza* is a somewhat similar paving in which the small cubes are not arranged in patterns. In all cases in which marble is employed, whether in mosaic or in the form of marble tiles or slabs, the bed and the material for setting should be lime mortar, as cement is very liable to stain the marble and discolour it.

Cement Paving. For many purposes cement paving may be utilised; this is usually formed of one part of Portland cement to one of sand, and should be not less than 1 in. thick, as very thin coats are apt to crack and come away from the concrete; if finer work be required the surface may be finished before it is set with a thin coat of neat Portland cement about $\frac{3}{8}$ in. thick, but the laying of this should not be deferred till the coarser rendering is set, or it will be liable to separate from it.

For external work the cement paving should



115. AIR INLET FLUE. 116. IRON HOLDFAST FOR FIXING JOINERY. 117. BRICK PAVING LAID HERRING-BONE. 118. PAVING BRICK WITH CHAMFERED ANGLES. 119. TILE PAVING

AIR FLUES, HOLDFASTS, AND PAVING

be at least 2 in. thick, and may be composed so far as the bulk is concerned of one part of Portland cement to four parts of small shingle free from salt, or of fine granite chippings, and finished with neat cement $\frac{3}{8}$ in. thick laid immediately after the coarser stuff, so as to set and become incorporated with it; or with crushed granite mixed with Portland cement, which is known as *granolithic paving*.

In all cases in which the finished surface is of an ornamental character, care must be taken in arranging any patterns that may be used, so as to centre with the spaces they are to occupy, and in adapting borders to any irregularities in the plan due to projections or other causes. This should be provided for in preparing the design, but the execution depends on the workman, and requires careful forethought and attention.

Tile Paving. Tiles are very largely used for pavings [119]. They vary greatly in thickness, size, shape, and colour; they may be of one plain colour throughout each tile, and throughout the whole floor, or tiles plain in themselves may be used in various colours to form patterns, or the tiles themselves may be of two or more colours. In places where there is no actual traffic over them—as, *e.g.*, in hearths—the tiles may have a glazed surface.

Tiles are laid on a floated face formed on a bed of concrete; they must be cut, if necessary, to fit irregular positions, are immersed in water for some time before laying, and are laid and jointed in cement. The cement bed should be about $\frac{3}{8}$ in. thick to allow of any slight unevenness in the tiles being adjusted.

Mosaic and Marble Paving. Mosaic floors, whether of tile or marble, are set out on sheets of paper, the small cubes of which they are composed being temporarily fixed to the paper so as to form the required design. They are laid in sections upon the prepared bed,

Channels and Gutters. If channels or gutters be required in any form of paving they must be prepared for in the concrete bed in such a manner that the full thickness of the paving can be formed at all points in the channel, and still give the required finished size for it.

Asphalt Paving. Asphalt is a good deal used for pavings. It must be prepared for like other pavings, and the surface on which it is laid should be thoroughly dry. It may be laid in any thickness from $\frac{1}{2}$ in. up to 2 in., and if it exceeds 1 in. in thickness, should be laid in two coats, which is always desirable when it is required to be absolutely waterproof. It can be turned up against the walls in a continuous layer, which in cases where water is liable to collect on the floor, is a great advantage. In road work the asphalt is sometimes laid as a powder and beaten with heated irons, but for floors it is more usual to heat the asphalt as for damp courses, and spread it while hot. [For wood block flooring, see Joinery.]

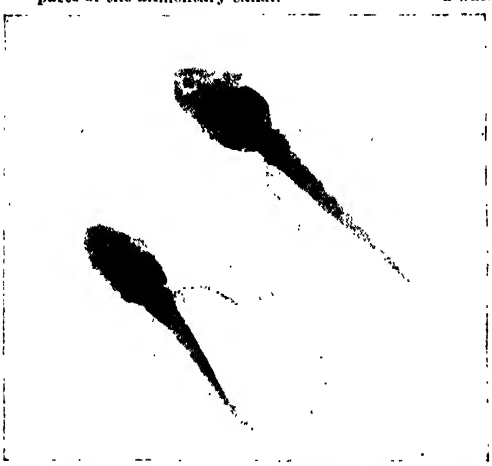
R. ELSEY SMITH

THE GROWTH OF A FROG SEEN BY THE X-RAYS

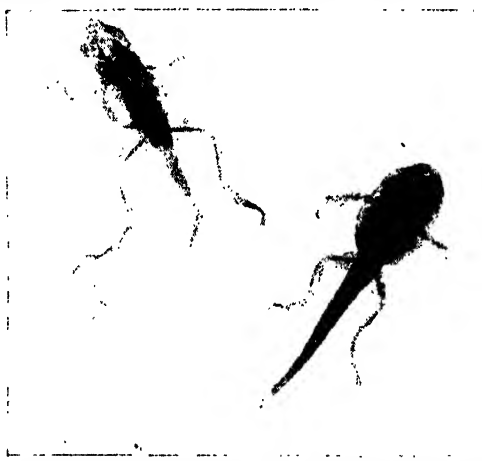
Tadpoles showing the development of a fish-like tail and the appearance of parts of the alimentary canal.

The development of bones of the head, and the alimentary canal coiled up like a watch-spring.

Further developments of the bones of the head, while the alimentary canal diminishes in size.



The alimentary canal situated entirely on the right side, the hind limbs taking form, and the fore limbs in process of unfolding.



The stage at which the animal leaps ashore as a frog, with shrunken abdomen, and transverse processes of vertebræ developing.

The ossification of the upper jawbone, and the vertebral column and head well developed, and the disappearance of the tail.

The greatly increased ossification of the apex of the vertebral column, and the bones of fore and hind limbs well developed.

Extinct and Extant Amphibians. Cæcilians. Newts and Salamanders. Frogs and Toads. From Tadpole to Frog.

AMPHIBIANS

Frogs, toads, newts, salamanders, and some other cold-blooded, backboned forms are often popularly regarded as reptiles, but in reality belong to a decidedly lower class, the Amphibia. The soft, slimy skin and the absence of scales and claws are distinctive characteristics of existing members of the class, but a more important point of difference is to be found in the nature of the life-history. A frog, for instance, does not hatch out of the egg as a miniature adult, but as a limbless tadpole, breathing by means of gills and presenting other resemblances to fishes. Later on, this larval form passes through a number of changes, together making up a "metamorphosis," by which it gradually comes to assume the form and structure of the adult. The fore and hind limbs sprout out, and air-breathing lungs are developed, while, in the frog, the gills entirely disappear. In some other amphibians, however, the gills may persist throughout life.

Extinct Amphibians. Some of the most ancient extinct reptiles with which we are acquainted possessed certain structural features which ally them to the amphibia, and have no doubt descended from creatures of the kind. As might be anticipated, the reptiles in question come nearest to the oldest known amphibia. These were the members of the great order of armour-headed amphibia (*Stegocephala*), the first backboned animals which entered into the possession of the land. They included a great number of forms, some very small, others of great size, which date from the coal period and became entirely extinct during the earlier stages of the Secondary epoch, being apparently unable to compete successfully with the rapidly evolving group of reptiles. The heads of these ancient types, and their bodies, more or less, were protected by an armour of bony plates.

Recent Amphibians. These are grouped into three orders: 1, Cæcilians (*Apoda*); 2, Tailed Amphibia (*Urodela*); and 3, Tailless Amphibia (*Anura*).

Cæcilians are limbless, snake-shaped forms, which burrow in damp earth, and are widely distributed in the tropical regions of both hemispheres. Their distribution, and the fact that they are devoid of any means of rapid dispersal, suggest that the group is one of great antiquity. And, as a matter of fact, these little creatures, although in some respects much specialised, come nearer the primitive extinct forms than the other existing amphibians. Numerous little bony plates, for example, are imbedded in their skin, representing the armour that was once characteristic of the class.

Tailed Amphibians. Most country dwellers are familiar with the little efts, or newts, commonly to be seen in ponds or ditches or crawling over the damp ground in their vicinity, In appearance they are not unlike lizards, but their movements are much more sluggish, while the slimy, scaleless skin and the clawless digits at once show them to be amphibia. The limbs sprawl even more than in reptiles, and the thumb is absent. Besides this, newts lay their eggs in water, and tadpoles hatch out from them. Our largest native species is the great crested newt (*Triton cristatus*), which is so called because, during the mating season, the male possesses a saw-edged fold or crest placed in the middle line of the upper side of the body.

Poisonous Types. Salamanders resemble newts, but are mostly larger, and, when adult, better suited for a life on land. The spotted salamander (*Salamandra maculosa*), common in damp woods in parts of central Europe, is black in colour, with orange blotches, giving it a very striking appearance. It is, in fact, a case of warning coloration, for a poisonous fluid exudes from the skin (as in most amphibia) which is highly distasteful to mammals, and if injected into the blood of small animals of that class proves fatal. An enterprising lady who investigated the matter gently pressed the tail of a salamander between her teeth, and experienced considerable swelling of the mouth and tongue, associated with the distressing symptoms of temporary dumbness.

The acquisition of poisonous properties by the skin has doubtless enabled amphibians to dispense with the armour they once possessed. These properties are no doubt the foundation of the superstition with which newts, frogs, and toads are regarded, but as they neither bite nor sting, and can be handled with impunity, and since in addition they wage unremitting war upon various small pests, there is no excuse for regarding them with antipathy.

Egg-laying Larvæ. It is interesting to note that the tailed amphibia are characteristic of the northern hemisphere, within the limits of which they are represented by very numerous forms. The giant salamander (*Cryptobranchus japonicus*), of Japan and China, is the largest of these, being about 6 ft. in length. But probably the most interesting member of the order is the creature known as the axolotl, of which a living specimen is here represented. It is an aquatic form native to Mexico, and possesses not only lungs, but red plume-like gills projecting from the side of the neck. The eggs are laid in water afert the usual fashion of amphibians. A good many years ago

it was discovered that, under certain conditions, axolotls kept in captivity lose their gills and change into a kind of salamander, and we now know that this takes place naturally in the southern part of the United States. The axolotl, then, as such, is neither more nor less than a permanent larva, which has precociously acquired the power of laying eggs, and, in Mexico at least, dropped the adult stage out of its life-history.

Many of the lower species of tailed amphibians retain their gills partly or entirely throughout life, this being naturally associated with an aquatic habit. Such forms are common in North America, and there is one curious species, the olm (*Proteus*), which inhabits the subterranean waters of the caves in the Austrian province of Carniola.

THE MALE SMOOTH NEWT SWIMMING

limbs take no part in aquatic progression, being folded on the breast.

The mottled skin of a frog in many respects harmonises with the surroundings, and serves the double purpose of protection and aggression. A large amount of change of colour can take place, somewhat as in the chameleon, but less rapidly and without so extensive a range of possibilities. Such changes are rendered possible by the presence of innumerable minute star-shaped cells (colour bodies) in the skin, which contain a dark pigment. Under the action of the nervous system these may be contracted to mere pins' points in size, or expanded to relatively large dimensions. In the former case the pigment is reduced to a small area, and the skin assumes a light, yellowish-green hue, as it does among grass. This state of things is reversed when the colour-bodies enlarge, as happens when frogs lurk among dark surroundings.

THE SPOTTED SALAMANDER

THE AXOLOTL

Tailless Amphibians. These include frogs and toads, which are the most successful members of the class, and are to be found in almost all parts of the world. On examining a common frog (*Rana temporaria*), we at once notice the short, tailless body, and the disproportionately long hind limbs, characteristics associated with the leaping habit. These points are even more obvious in the skeleton, which should be compared with that of the giant salamander, a tailed form.

The frog is also an expert swimmer, and the hind feet are webbed. They execute movements closely resembling those employed by human beings for the same purpose, but the fore

THE OLM FROM THE CAVES OF CARNIOLA

The insects which make up a large part of the food are captured by means of the long, sticky tongue, as in chameleons; but here the mechanism is somewhat different. The tongue is attached to the front of the floor of the mouth, and, in a state of rest, its forked tip points backwards down the throat. When brought into action the free part of this organ sweeps upwards and forwards out of the mouth, its end brushing past the roof of the mouth cavity, taking up some of the sticky fluid discharged by a group of small glands. The prey secured,

TWELVE SPECIES OF FROGS AND TOADS


GOLDEN TREE FROG


COMMON FROG


AUSTRALIAN TREE FROG


COMMON TOAD

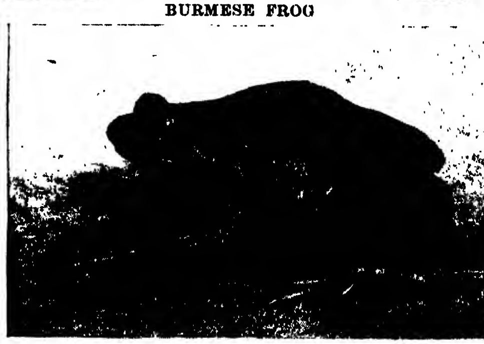

EDIBLE FROG


NOISY FROG


BULL FROG


BURMESE FROG


FEA'S FROG


PAINTED FROG


MOORISH TOAD


HORNED FROG

the extraordinary tongue is rapidly drawn back to its former position.

Frogs and all tailless amphibians breathe entirely by the lungs and skin, the gills and gill-slits of the tadpole being entirely lost in the adult. The life-history of the frog presents us with the best practical illustration of evolution. The limbless little tadpole which hatches out from the egg possesses a large swimming tail, and breathes by three pairs of plume-like gills, much like those of an axolotl. Later on these are replaced by the so-called "internal" gills, vascular folds on gill-slits which place the cavity of the throat in communication with the exterior. A fold now grows back over the external gills (which are shrivelling) and the gill-slits, its edge fusing with the wall of the body, except at one place on the left side, where a small round hole ("spiracle") is left for the exit of water which has entered the mouth, traversed the gill-slits, and bathed the gills for the purpose of breathing. Meanwhile, the lungs are growing out as pouches from the under side of the back of the mouth floor, and begin to share the work of respiration, gradually supplanting the gills, which ultimately disappear, while the gill-slits close. These alterations involve profound changes in the heart and blood-vessels. To begin with, the heart is essentially like that of a fish, consisting of two principal chambers—an *auricle*, which receives the impure blood of the body, and a muscular *ventricle*, which pumps it to the gills for purification. After this it is distributed to the body at large.

A TWO-LEGGED SALAMANDER—THE MUD EEL, OR SIREN

The Lungs and the Heart. As the lungs begin to act they pour pure blood into the auricle, which becomes divided into two by a partition, the left moiety (left auricle) receiving the pure blood in question, and the right (right auricle) acting as a receptacle for impure blood. As the ventricle remains undivided, the two kinds of blood it receives from the auricles to some extent mix in its cavity, but, owing to its spongy wall and several other structural features, the mixing is only partial. The result is that, in the adult animal, impure blood is pumped to the lungs and skin, pure blood to the head, and mixed blood to the rest of the body.

From amphibia upwards to reptiles, birds, and mammals, evolution has brought about a gradual perfecting of the arrangements for keeping pure and impure blood separate. But only in birds and mammals is this end completely attained, and the whole of the body supplied by perfectly pure blood. Hence the success of these two classes of backboned animals.

Other striking changes mark the conversion of a tadpole into a frog, and of these the most obvious are the gradual absorption of the tail and the growth of fore and hind limbs. While the young tadpole is a vegetarian, the adult frog is highly carnivorous, and the long, spirally coiled intestine of the former is in marked contrast with the relatively short, convoluted intestine of the latter.

Paternal Care of the Young. Our native frogs and toads do not trouble themselves about the well-being of their eggs and young, but this is far from being the case in all members of the order. The male of the midwife toad (*Alytes*), native to parts of Europe, carries the egg-strings round his legs until they hatch out, and takes the greatest care lest they should dry up. Much more remarkable are the arrangements in a South American species, in which the male possesses a pair of membranous croaking sacs, which primarily serve as resonators to increase the musical effect of the voice, under the skin of the under surface. Into these pouches the just-laid eggs are introduced, and the entire development there takes place, the young remaining in this curious paternal nursery until they have assumed the adult form.

Considerable maternal solicitude is shown by some members of the order. In the Surinam toad (*Pipa*), for instance, the eggs are placed on the rough skin of the back, within cavities of which they pass through their development changes. In other cases (*Nototrema*) there is a pouch in the skin of this region which answers the same purpose. Many tree-frog mothers construct nests in which to deposit their eggs, the most remarkable case being that of the South American ferreiro (*Hyla faber*). Here the female builds a circular mud wall in the shallow part of a pond, within which the eggs are laid. A considerable part of the life-history is passed in this neat and comparatively safe "nursery." The success of many tailless amphibians in the struggle for existence is partly due to their possessing strong parental instincts, which give their offsprings a better chance of survival.

The Struggle for Existence. In a certain sense it may be said that amphibians occupy the same sort of place in the animal world that ferns and the like do among plants. For in both cases there is more or less dependence upon moist conditions during part of the life-history, a sort of memento of the purely aquatic life led by remote ancestors. This is somewhat of a handicap in the struggle for existence. An amphibian is obliged, so to speak, to "fight on a double front." The tadpole competes with aquatic forms, the adult with terrestrial ones, or both. There is some compensation for the latter, however, as it is often able to use the water as a place of refuge.

J. R. AINSWORTH-DAVIS

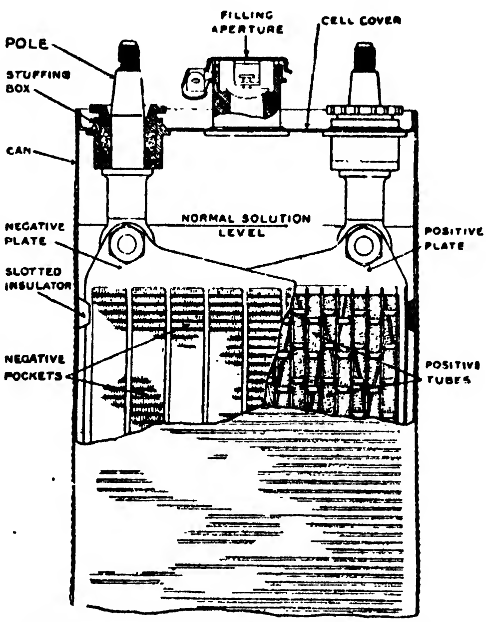
The Secondary Cell. The Plante and Faure Types. Modern Cells. Capacity, Care, and Uses of Accumulators.

ELECTRIC ACCUMULATORS

For many years it was held to be a distinct drawback that it was not possible to store electric energy on any scale commensurate with that of the storage of gas. In some senses this is true today, but the advances which have been made during the past few years in the perfecting and application on the large scale of electric accumulators has to a great extent removed this reproach. For instance, **236** shows a battery in use at Wolverhampton, consisting of 230 cells, which has an output of 2310 amperes for three hours, and of nearly 5000 amperes for one hour, and it will for short periods give out as much as 9000 amperes. At Manchester there is a battery of 210 cells which, on a one-hour discharge rate, gives 8400 amperes, and for short periods 15,000 amperes.

The Secondary Cell. These results have, however, been obtained from very small beginnings, and to the majority of present-day electrical engineers the mention of secondary batteries is associated with small glass cells, and generally unsatisfactory results.

A *secondary cell* means one which is not in itself capable of generating a current, but only acts as a cell after a current has been used to charge it. The current thus supplied to it produces chemical changes in it, and puts electrical energy into it in producing these chemical changes. Under reversed conditions the cell will give a useful discharge of current, thus redelivering the greater part of the electrical energy which it has received. Such a battery is capable of acting as *an accumulator*, though what it accumulates is energy, not electricity.



229. DIAGRAM OF AN EDISON ACCUMULATOR

The ordinary accumulator cell in general use is a lead-acid cell—that is, it consists of two lead electrodes immersed in dilute sulphuric acid. To charge it we pass through it an electric current from a dynamo, when the positive plate becomes covered with a layer of dark brown peroxide of lead, and the negative plate presents a surface of clean, spongy lead. After being thus charged, the cell is ready in turn to act as a source of current, giving out its stored energy. The spongy lead plate now is acted upon chemically, like the zinc in a primary cell, while the peroxide on the other plate, which is the kathode, acts as an excellent depolariser. There are other kinds of accumulators using other combinations, such as the nickel-iron alkaline cell.

Planté's Cell. The original discovery of the lead secondary cell was made by Planté in 1860, but in those days it took so long to "form" the plates by repeated charging and discharging that the accumulator was a curiosity, and little more. In recent years, however, there has been a partial, if not complete, return to Planté's principle, and some of the best makers work on his lines.

Faure's Cell. In 1881 Faure modified the Planté process by giving the two lead plates a preliminary coating of red lead. This was found to increase the electrical activity of the cell, but rendered it mechanically weaker.

A form of plate was soon evolved in which the electrodes consisted of lead grids, in the interstices of which the active material is placed. This type of plate has gone through many modifications, and is used today by some of the largest manufacturers. It is now usual to mix a small amount of antimony with the lead of the grid to make it harder. The active material is a paste consisting of litharge mixed with dilute sulphuric acid.

Modern Cells. The cells we describe as typical of modern practice are, however, made in a different way. The positive plate [**230**] consists of a lead-antimony grid with a number of holes. Into these holes are pressed rosettes made of pure lead tape, coiled together and then pressed into the holes, the whole being finally compressed hydraulically to ensure each hole being filled with the lead rosette. The negative plate [**232**] is made in two

halves, riveted together after the insertion between them of the active material, which is thus held in position.

Another form of positive plate which is used in some of the largest cells is shown in **234**. Here the plate is cast of pure lead with corrugations as shown, and no paste is used, the plate being formed by repeated charges and discharges, which corrode the surface into peroxide, as in the original Planté method. The Chloride Company, who manufacture the types of plates [**230-232**], use specially treated wooden separators, of the form shown in **231**, between the plates. This has entirely superseded in their practice the glass rods and ebonite forks which were formerly the general rule.

Capacity of Lead Accumulators. The ability of a cell to serve for a greater or lesser amount of storage is termed its *capacity*. The capacity of a cell is expressed in ampere-hours. Thus a cell which can give out a current of 100 amperes for eight hours would be said to have a capacity of 800 ampere-hours. But to comprehend the significance of this mode of expression it is necessary to know something of the voltage changes which take place during charge and discharge of the cell.

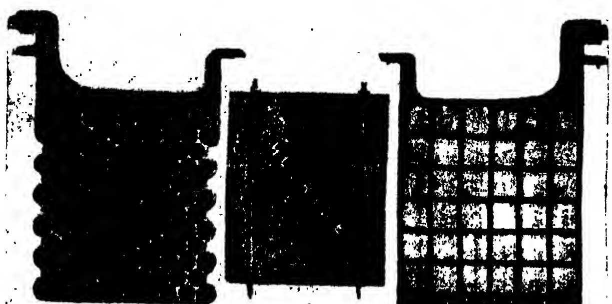
When a cell has been fully discharged the voltage is about 1·85 volts. As soon as a charging current is applied its voltage rises to a little over 2 volts [**237**], and gradually goes up during charging until, when the cell is fully charged, it is about 2·5 volts. When this voltage is reached, bubbles of gas are given off from the plates, or, in popular terms, the cells begin "to gas," and any further current passed into the cells simply decomposes the electrolyte, and is wasted. If, now, the cell is discharged as shown on the diagram [**237**], the voltage immediately falls to about 2 volts, where it remains until towards the end of the discharge, when it falls to 1·85.

Efficiency of the Cell. The efficiency of the cell—that is, the ratio of the electrical energy put in to the electrical energy given out—depends upon the rate of charge and discharge, being highest when the operations are carried out slowly. Commercially, a definite time is taken, and the capacity of a cell is stated in the number of ampere-hours it will give on a 3, 6, or 8 hour discharge. A safe rule as to the current one may take from a cell is not to exceed 7 to $7\frac{1}{2}$ amperes per square foot of positive or negative plate surface.

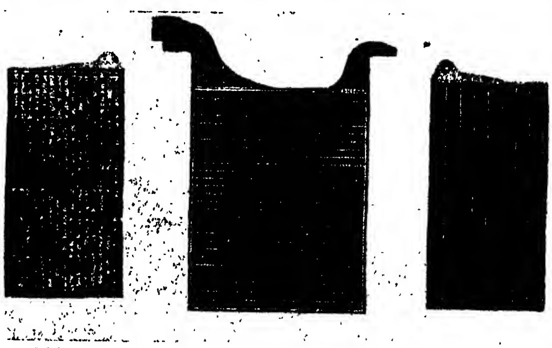
The effect which varying the rate of discharge will have upon the efficiency and capacity of a cell is shown in the following table.

EXPERIMENT WITH AN ELECTRIC ACCUMULATOR

Hours taken for cell to discharge	Current rate of discharge in amperes	Calculated capacity at this rate in ampere-hours	Efficiency
10	10	100	95·3
9	10·8	97·5	92·8
8	11·8	94·5	90
7	13·2	92·5	88
6	14·7	88·5	84·3
5	17	85	80·9
4	20·4	81·5	77·6
3	25·6	77	73·3



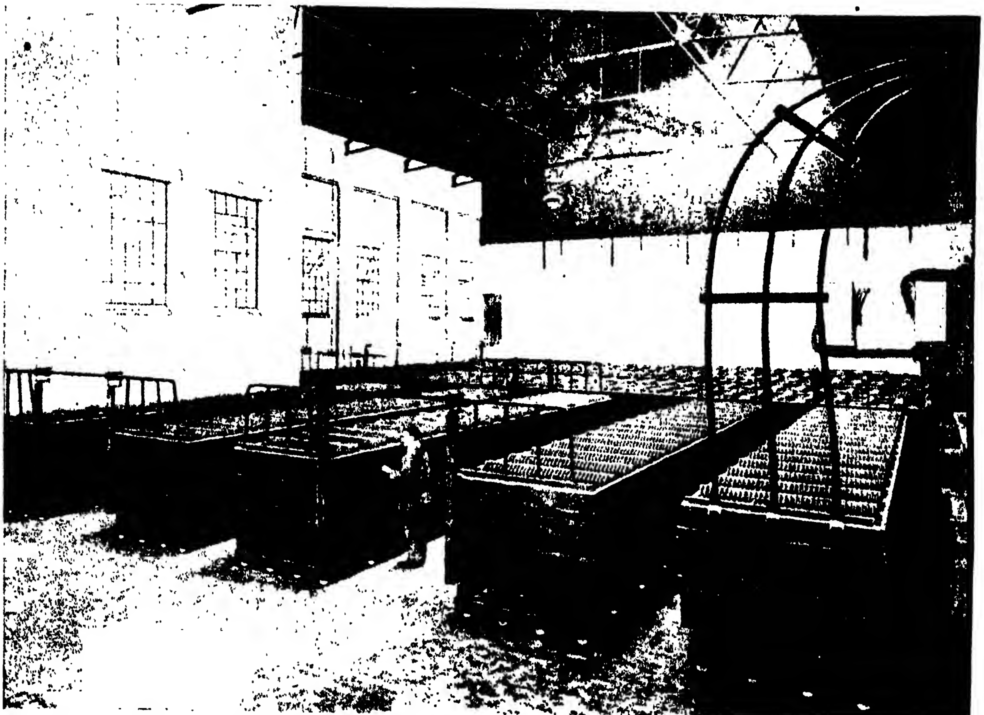
230. POSITIVE PLATE **231.** SEPARATOR **232.** NEGATIVE PLATE



233. EDISON POSITIVE PLATE **234.** POSITIVE PLATE
235. EDISON NEGATIVE PLATE

Care of Accumulators. When fully charged, the positive plate of a lead accumulator consists largely of lead peroxide, which is of a rich plum colour, while the negative plate of spongy lead is dull metallic grey. When discharged, both plates are largely ordinary sulphate of lead, which is whitish-grey. The colour of the plate is therefore a rough guide to the condition of the cell.

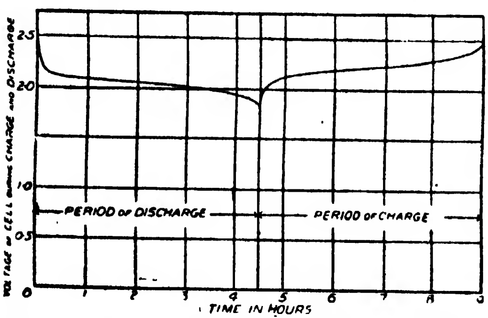
A more accurate test, however, is to take the terminal voltage of the cell. If below 1·9 volts, it is nearly discharged. The best way is to keep periodical records of the specific gravity of the acid. This increases as the cells are charged, and should be about 1·21 when the cells are fully charged and 1·175 when they are completely discharged. Intermediate readings give an indication of the state of the cells. The directions sent out with the cells by the makers should be most carefully followed; and if the battery is a large one it may be well to enter into a maintenance agreement with the makers, who are always ready to contract to keep them



236. GENERAL VIEW OF THE WOLVERHAMPTON ACCUMULATOR BATTERY

in order for a term of years. It is very important that batteries of accumulators should be placed in separate well-ventilated rooms, in which metal fittings should, as far as possible, be avoided, lest active corrosion occur owing to the acid fumes given off from the cells.

Uses of Accumulators. An account of the uses of batteries of accumulators in large central stations in conjunction with boosters is given in page 2204, where it is shown that their



237. VOLTAGE VARIATIONS DURING DISCHARGE AND CHARGE

employment enables large savings in fuel to be made. Small accumulators are also now largely used in portable form in motor-cars and motor-boats for ignition purposes, and in cable-testing and telephone work. They are also finding favour for driving electric vehicles.

The Alkaline Accumulator. This type of cell, better known as the Edison accumulator, has reached its present form through many tribulations. The illustrations [229 and 235] show how the latest types of this cell are made. The electrodes are nickel and iron oxide, immersed in a solution of potassium hydrate; the cell voltage measured on a 5-hour discharge rate is 1·20 volts, the ampere-hour efficiency under these conditions being about 70 per cent., and the watt-hour efficiency about 60 per cent. The positive electrodes [233 and 238] consist of a number of steel tubes which are filled with alternate layers of nickel hydrate and powdered metallic nickel. The tube is made of a spiral of steel tape, strengthened by the small steel bands shown. A number of these fixed in a nickel steel frame form the positive plate.

238. POSITIVE OR NICKEL TUBE OF EDISON ACCUMULATOR

The negative plate [235] consists of finely powdered iron oxide mixed with a small quantity of mercury packed into pockets made of finely perforated thin nickel steel. These are afterwards placed, as shown, in a light steel can and subjected to heavy pressure. The electrodes are placed in a welded steel case, which is then filled with the potassium hydrate solution. These cells are much lighter for a given output than a lead cell, and, as experience is proving them to be capable of withstanding rough usage, they are coming into considerable favour for electric vehicle work.

SILVANUS P. THOMPSON

Putting on the Strings. The Octaves. Tuning. Correct Attitude of Player. Finger Preparation. Right and Left Hand Practice.

THE HARP

When the beauty of outline and charm of tone of the harp are considered, it may seem strange that this instrument is nowadays seldom heard in the home; but let the student who has bought a harp attempt to master it without the assistance of a tutor and he will speedily discover why it was superseded by the pianoforte. A child can go to a keyboard and elicit sounds which are in accord with each other; but with the harp, the player has to tune, and continually to keep in tune, upwards of forty strings. On the first occasion he will probably have to replace several which are broken. It is therefore necessary that the student should appreciate the difficulties which lie in wait for him, and endeavour to overcome them by carefully following the instructions given.

Stringing the Harp. It is false economy to get cheap harp strings; only those of the best manufacture should be used. Their tone is of better quality, and, being more evenly graded in size, they last longer. The thickest and longest strings are those nearest the pillar, giving the deepest tone; then they diminish in length and thickness till the high treble notes are reached. Use a gauge to ensure that each size is correct. This can be obtained wherever the strings are purchased.

The first thing to note is that all the C strings are red in colour. All the F's throughout the scale are of dark blue. The other strings are white. This enables the correct notes to be identified rapidly in playing. Beginning at the pillar we have the bass octave, which consists of wire-covered strings. These of good quality cost about 2s. each. In a full-sized Gothic concert harp the strings nearest the pillar are C (red) and D. The old-fashioned single-action harp has a shorter compass of six octaves, from E to E. In that case the longest string would be E, and the next one to it F (blue).

How to Put On a String. After unrolling a wire string, see that it is overspun equally. Pass one end of it through the eye-hole in the first "wrest-pin" of the neck of the instrument, and tie a knot securely at that end. Take out the corresponding wooden peg in the sound-board, and pass this end of the string through the aperture. Replace the peg so as to hold it tight, and bring the upper part of the string between the studs of the levers. Adjust the tuning hammer, or harp key, on to the wrest-pin. Wind the latter round to the right till the string becomes taut. If restringing throughout, do not draw up any one string to its proper pitch until the others have been put on and made fairly tight. When the instrument is up to pitch, the tension on the entire frame is very great. It is not advisable, therefore, to impose a sudden strain on any one part of the neck. The stress should be increased gradually and equally.

The Fifth Octave. Having strung the bottom C (red), D, E, F (blue), G, A, B, C (red), D and E, and left them slack, the fifth octave receives attention. The material here is of gut. Later, when ordering strings the student will be able to indicate the exact gauge best suited to his hand. If the string is insufficiently stout, it will jar unpleasantly when played. It must not be too thick or the touch will be difficult. Ladies, as a rule, prefer thinner strings than men, who are able to get a richer tone from a material furnishing more resistance. After unrolling a gut string, hold it to the light, and see that the texture is clear and that it is not lumpy. If flecked or perished, it is useless to put it on. In this octave the lowest string is F (blue). Then come three white strings (G, A, and B), C (red), D, and E. For the fifth octave the best quality of string costs 1s. each.

In the fourth octave there are seven gut strings of smaller gauge than in the preceding set. Of best quality, they cost 10d. each. As before, the lowest string is blue; this is followed by three white, one red, and two white. For the third octave another set of seven, still smaller in gauge, must be adjusted. If superfine, these cost 8d. each.

Continuing higher up on a full-sized harp, there are two more sets to adjust—those of the second and first octave, the latter being the shortest and of the smallest gauge. The respective cost of these is 6d. and 4d. each. Thus, a complete set of five octaves of gut strings, if bought separately, comes to 23s. If purchased together, they may be had for £1. According to the size of the harp, a complete set of wire bass strings costs either 16s. or £1.

Measurement of Octaves. In a musical sense octaves are reckoned not from the blue, but from the red strings—from C to B inclusive—although the gauges are calculated from F upwards to E inclusive. If, instead of strings we had pipes—as in the church organ—to obtain the sound of the bottom C in the double-action harp 16 ft. of tubing would be necessary. As the harp is not 16 ft. high, what the string lacks in length is made up in weight. That is the object of having the core of gut overspun with wire. In the same way the C above the lowest B should be 8 ft. in length, or half the length of its octave below. But still there is no room in the harp for this, so the C, D, and E continue to be overspun. The blue F string of very stout gut is the thickest without

metal covering. Above, the next red string represents the 4-ft. pipe in an organ. This 4-ft. octave is also called the *little octave*, because in print the notes are designated by letters of small type, whereas to represent the *great octave* below they are typed in capitals. The octave C above the "little" represents the 2-ft. pipe in an organ. It is also known as the "one stroke" octave, because this section of the compass is represented by a single stroke, or accent, after each letter. Proceeding to the three red strings above, we have respectively the 1-ft., 6-in., and 3-in. pipes of an organ, these being denoted in print by two, three, or four strokes after the letters. Therefore, the vibrating lengths of the top strings of the harp are very short. If it were not for the sympathetic vibrations given out by the longest strings below, these high strings would be scarcely audible. Through the sounding-board, however, their tone is amplified by their longer neighbours, and if the treble strings are good, they have a beautiful silvery effect.

Tuning. Before the beginner succeeds in tuning the harp with facility it will take considerable practice. His best plan at first is to have recourse to the keyboard of a piano or harmonium. It may be somewhat bewildering to the eye to find that there are seven flats in the signature of the natural key of the double-action harp, because it is tuned in C♭. Test the piano by a tuning fork. If it is fairly up to pitch, tune the red string in the centre of the harp representing the 1-ft. octave, or the note C (third space, treble clef) to the B♮ on the piano, for B♮ is synonymous with C♭. But the scale of C♭ has seven flats, whereas the scale of B has only five sharps, so it is easier for the beginner to think of the latter rather than the former. Therefore, for the moment, forget all about the C♭, and tune the third red string below to the octave B or the note under the first ledger line. Then get a fifth above the bottom note, F♯, on the first white string over the blue. Try these three notes together—B, F♯, and B on the piano.

Sound the first red string again, and tune the blue string a fifth below it to the E (first line, treble clef) on the piano. Prove together the three notes—two red and one blue—represented on the piano by B, E, and B. Next take the two white strings above the blue and the red. Tune them respectively in fifths to F♯ and C♯ on the piano, although on the harp these are really G and D strings. Having done this, tune the octave below the D to C♯ on the piano. Prove the three white strings, D, G, D, by the C♯ F♯, and C♯ on the keyboard. Taking the lowest string, get the A above it (second white this side of the blue), and tune it to G♯ on the piano. Prove the three, D, A, D, by the C♯ G♯, and C♯ on the piano. Taking the middle string of these, tune the E string a fifth above it to the D♯ (with the G♯) on the piano. From this last E string tune the octave E string below, to the D♯ on the piano. Prove this with the middle A string, or G♯ on the keyboard. From the lowest of these three strings tune the white B string—next below the pitch C (red)—a fifth together to the notes D♯ and A♯ on the piano, proving with the octave string above. By this means the scale between the 2-ft. and 1-ft. C's on the harp has been laid, and all the strings, from the red C up to the second E above, have been drawn up to their proper pitch. Thus, the first greatest strain has been placed on the centre of the neck of the instrument, which, like the keystone of an arch, is that part best able to bear it.

Octaves. Having laid the scale, tune the strings above and below in ascending and descending octaves. Begin with the middle blue string (F on the harp). Tune the corresponding blue string above it to agree with the note E (first line, treble clef, and E on fourth space above) on the piano. Tune the three white strings next above respectively to the F♯, G♯, and A♯ on the piano. The red strings (C's on the harp) will then be reached. Tune these to the octave B's on the piano. Continue the operation, checking each string by the piano notes until all the top strings have been tuned. Then take the lower notes. Begin with the first white string below the red. Tune this to A♯ on the piano, with its octave below. Follow on with the next white string, tuning it to G♯. The bass clef on the harp usually begins with the first blue string below pitch C. Tune this blue string (F on the harp) to the E on the piano (second ledger-line above the staff) and the E below (third space, bass clef). Follow with the two white strings (tuned to D♯ and C♯), the two red strings (tuned to B on the piano), and so on down the scale.

As soon as the beginner gets accustomed to, and remembers, the various sounds required, he will be able to dispense with the aid of the keyboard. Great harp-players have their different methods of tuning. The late Mr. Oberthür was of opinion that "to tune well and correctly cannot be learnt by rules, as this depends principally upon a correct and musical ear." Yet that master taught many pupils how to tune their instruments by showing them rather than telling them the way. When dealing with so subtle and elusive a force as musical sound, it is easier to convince by demonstration than to explain by word alone. Briefly, however, it may be said that, when desirous of making a brilliant effect, some harpists have a knack of tuning the strings as they ascend a shade sharp; and, in order to get greater depth and fulness of tone towards the bass, the long strings are intentionally left a trifle flat in the extreme octave. This, the purist may argue, is not correct tuning. Nevertheless, it is more than justified when it improves an otherwise dull instrument.

Position of the Player. Adjust the music-stool in height so as to bring the chin of the performer level with the neck of the harp when the instrument is drawn back, and turn out the feet to give them easy access to any of the pedals. Draw the harp towards the right shoulder, and let it rest against the right knee.

Generally speaking, those notes written in the treble clef are played by the right hand, and

those in the bass clef by the left hand. The little finger is not used in harp playing. Place the thumb, first, second, and third fingers of the right hand respectively on the F (blue string, first space), E (first line), D, and C (red). Keep the thumb erect, and bend the other fingers gracefully towards the palm of the hand. The knuckles must be kept up. Curve the joints, and avoid bringing the palm towards the player; it is the back of the hand, rather, which should face him. Do not rest the wrist on the soundboard, but when playing in the middle octave keep it elevated. In ascending to the shorter strings, however, this wrist support is allowable. Freedom of finger action must be aimed at, and the carriage of the hand should be light in quickly ascending arpeggios or scales. Too much attention cannot be paid to getting the correct position of the hand. This is not easy at first, owing to the way in which, except in the bass, the fingers must be compressed. The idea is not to pick at the strings with the nails, but to strike with the fleshy tips.

Right Hand Exercise. With the third finger of the right hand strike the middle C (fourth red string from the player's body). Bend the finger elastically. Do not move the wrist or arm; the motion should only affect the finger-joint. In the same manner strike the D (above the red C) with the second finger, the E with the first finger. Then proceed to the blue string F. To sound this with the thumb in an upright position, bend the digit slightly at the thumb-joint. Avoid motion of the wrist or arm. Remember, whenever a string has been struck, that the thumb must return at once to its perpendicular attitude. Repeat this exercise (with the third, second, first finger and thumb) slowly. Try to get the sounds equal in clearness, softly at first. When the hand gets accustomed to the strings, use more and more force, and increase the speed.

Adjusting the fingers in advance is an important matter in harp playing; it prevents unnecessary motions of the hand. The student must cultivate the habit of placing the fingers, before they are needed, softly on the string or strings about to be struck. Therefore, before sounding the blue string with the thumb, prepare the third finger on C, the red string below, so that the exercise may continue equally. In like manner, before the C is struck, get the second finger into position for sounding D.

Although the notation on paper in an ascending scale goes from left to right, and has to be played on the harp from right to left, towards the player, the beginner will soon accustom himself to correct transposition of the necessary movements.

Left Hand Exercise. The harp player has several advantages over the pianist. If the hands are spread out before one, it will be observed that the right thumb points to the left and the left thumb to the right. This means that, in a parallel passage on the keyboard for both hands, while one hand begins with the thumb, the other begins with the little finger, and so on, numerically reversing the order of each digit. Now, place the palms of the hand together towards each other, as in the attitude of prayer, instead of placing them away from each other. The left hand is thus the exact counterpart of the right.

Fingering. On the harp, therefore, the fingering of the two hands in parallel passages, ascending or descending, is uniform, instead of being dissimilar, as on the piano. Repeat, therefore, with identical manipulation, but an octave lower, the exercise for the right hand just given. Place the third, second, and first fingers and thumb of the left hand respectively on the red string below that struck by the third finger of the right hand, and the B, E, and F above. Be careful to place the fingers in the middle of the length of the strings. Keep the thumb up. As before, the motions should be from the fingers. Avoid moving the wrist or arm. This will be more difficult to do at first with the left hand. Absence of support from the body of the instrument, which the right arm has, makes the task seem almost impossible at first, but steady determination to do the right thing will presently cause the hand to obey the wishes of the mind. At first, softly and slowly, strike the four notes in succession from the C to the F, increasing the speed and strength gradually. Do not continue the exercise when fatigued; rest for a while, and begin again later. When this study can be played clearly by each hand separately, try it with both together. Considering that the fingers of the hand each possess a different strength, the tendency is for their movements to lack steadiness. This uncertainty the beginner must strive to overcome. In the absence of a master, the best way to do this is to practise with a metronome, and make each sound with absolute regularity, increasing the speed of the exercise gradually.

Inverting the Order. Now reverse the progression of the notes. After ascending from C to F as before, descend to the C. Be careful to anticipate each sound by placing the finger needed for the next string upon the latter before its time comes to strike. Do not be in a hurry; speed will come later. Try the same exercise with the left hand, keeping the elbow well up. Bad habits, which are easily contracted, usually arise from over enthusiasm when beginning to learn, and continuing practice when tired. The result is rigidity instead of elasticity of movement. The one thing in harp playing which the student must resolve to avoid is stiffness as opposed to gracefulness.

This is a difficult fault to remedy, so let the student, in following the beaten track alone, beware of the ruts; and, however easy progress may seem, avoid practising for too long a time at first.

ALGERNON ROSE

Processes in the Manufacture of Oilcloth and Printing Floorcloth and Linoleum. Seasoning.

FLOORCLOTH AND LINOLEUM

Floorcloth and linoleum take the place of purely textile products, and they have a textile basis in their jute canvas backing. The work of converting plain rough canvas into a smooth and durable covering for floors, however, involves a set of operations entirely different from that of converting fibre into cloth or from the ordinary course of cloth finishing. In manufacturing either of these commodities, advantage is taken of a peculiar property, possessed by certain oils and not possessed by others, of extracting oxygen from the air and of drying to a resinous state. Linseed oil, prepared from the seeds of the flax plant, is one of the best drying oils, and *linoleum*, the name coined some fifty years ago by the inventor of this improved form of oilcloth or floorcloth, was made by telescoping into one the Latin words for flax and oil.

The Making of Oilcloth. Raw linseed oil has moderate drying properties, and boiled linseed oil, made by boiling the oil in conjunction with a little *litharge* (monoxide of lead) and red lead, possesses the power in a remarkable degree. This capacity for drying is not lost when a pigment is added and the boiled oil is made into what is virtually a paint. In making oilcloth the canvas is coated back and front with such a paint. In the first place the jute is coated carefully with animal *size* to protect it from the acids formed by the drying of the oil, which acids would otherwise speedily destroy its strength. The sizing may be done by hand, as in the manufacture of the best oilcloths, and be laid on by a brush. In that case the canvas to be treated is nailed to an upright frame under a sufficient but not excessive tension; and imperfections in the surface are removed and loose fibre on the face of the cloth is rubbed down with blocks of pumice.

Painting. When the size has dried, the canvas receives its first coat of thick paint made by mixing together boiled oil and a mineral colour, usually the red oxide of iron. The paint is laid on with trowels like those used in plastering, and with the same tools the excess is scraped away. The first coat is left to dry and a second coat is given at the back. The first layer on the side of the cloth that is to form the face is smoothed, when dry, with pumice, and two, three, or more coats are added upon the face, the number of applications depending upon the quality of the goods. The last coat is applied with a brush for the sake of the greater smoothness of surface, and, when this has dried, the canvas is cut from the frame and sent to the printing-room to receive its coloured pattern. Great importance attaches to the manner in which the cloth is *seasoned*, and, if it is to wear well and not to exhibit shrinkage and expansion in use, it must be hung for a sufficient time, after printing, in a warmed and airy room.

Most of the oilcloth made is not hand-coated, but treated more quickly in machines fitted with troughs to contain the colour, and rollers for applying it, with a rotary brush for laying on the finishing coat.

Linoleum Manufacture. One of the first attempts to produce a thicker, warmer, and more resilient covering than oilcloth resulted in the manufacture of *kamptulicon*, in which masticated rubber took the place of the oil now used in making linoleum. This is not the only textile direction in which linseed oil and its concomitants have replaced rubber, for something of the same kind has happened in making cheap mackintoshes. In linoleum the oil is used to form a cement which shall hold together particles of cork. This cake of oil and cork is laid upon the canvas, and forms the surface upon which the printing of any pattern is done.

The cork used is chiefly the waste from the factories in which bottle corks are cut, and its reduction to a suitable size is done at two operations. After the cuttings have been sifted to remove foreign matter, they are passed into a machine fitted with serrated steel discs for breaking the cork into pieces the size of peas. The broken cork is then ground between flat millstones to as fine a powder as is required, and is dried in ovens to expel all moisture.

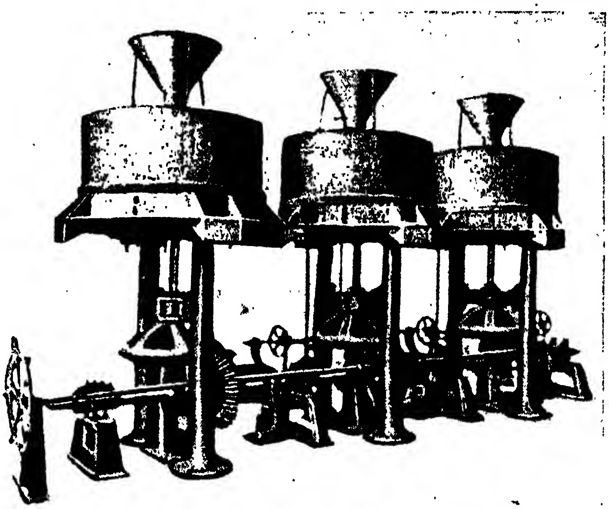
Mixing the Cork and Oil. The oil with which the cork is to be mixed is boiled, and at the same time aerated, and in the stringy consistency of birdlime it is reheated with the addition of rosin and of kauri gum. This mixture is run into pans, where it cools in the form of flat cakes. *Cement* is the name given to the compound, which is made ready for use by being cut into portions and heated. The cement is fed through steam-heated rollers, of which there are two revolving in one plane, with a third beneath them both. As the warmed cement comes beneath the upper rollers, it receives a supply of cork dust from a hopper fixed above the junction of the upper pair, and the cake passes out of this, the first mixing-machine, in a flat strip with a cork surface. The strip is led into a second mixing-machine fitted with a drum, inside which are beater arms to intermix the material with a measured quantity of colouring matter needed to give the mixture the required brown or red shade. From this drum the mixture is emptied into a third machine, in which the mass can be heated by steam to soften its consistency.

The mixture is minced by chisel-edged knives into a uniform dough, and passed into a fourth

mixer, where it is kneaded by knives and passed out through a pair of rollers, one of which is heated by steam and the other cooled by an inward circulation of water. The dough adheres to the cold roller, and is scraped away from it in a continuous thin sheet by a stationary knife. The sheet enters a fourth machine, also supplied with hot and cold rollers, and is scraped from the latter by nail teeth set on the surface of a cylinder. Thus the mixture is reduced to a granular state, and in this form it is pressed upon the surface of the canvas.

The canvas, rolled in a continuous length of one hundred yards or so, is led between a series of squeezing rollers, two of which are heated and the others continually cooled. The ground-up cork and cement is fed to the canvas upon a wire lattice which travels through a steam chest and delivers the mixture in a plastic state. The coating is pressed firmly into the interstices of fabric, and it remains only to give the back a protective layer of size and pigment, and to hang up the linoleum until it is dry enough to print.

Printing Floorcloth and Linoleum. The printing both of linoleums and oilcloth is done on long, flat bed machines, by means of blocks of wood or metal in which the design is



A BATTERY OF CORK GRINDING MACHINES

But all surface colouring is doomed to disappear as the surface wears away, and to avoid this wearing out of the pattern *inlaid* linoleum was invented, and by gradual progress its manufacture has been brought to remarkable success.

Inlaid Linoleum. In manufacturing inlaid linoleum, continuous sheets are formed of the colours required for the design. These sheets of coloured cork and cement are passed under cutting rollers, which punch out the pieces of sheet composing the design. The pieces are automatically ejected from the cutters, and attached by needle points to an endless belt, which carries them to the cylinder on which the inlaying is done. The pieces are collected and assembled by machine, fitted, and rolled off continually, to be attached with cement to the canvas, and to be compacted together under the pressure of heavy rollers. The method is not the only one in use for obtaining through-coloured linoleum. In another system the canvas is covered first with a thin layer of linoleum, to which is applied granulated linoleum of separate colours by means of rotary stencils. The foundation and coloured patterns are heated and rolled together, and the process produces the blurred, carpet-like effect that is to be seen in high-class cork carpets.

LINOLEUM AND FLOORCLOTH PRINTING MACHINE

raised in relief. One block is provided for each colour, the position of each block is fixed, and the fabric travels beneath them. The blocks are supplied with paint from pads fed from troughs and rollers; the position of the cloth is adjusted with exactitude by gauges; and the blocks are pressed down in succession to impress the separate colours and the outline of the pattern. The designs are printed in thick paints, of which the best have wonderful wearing properties.

The seasoning of linoleum before use is of even greater importance than in the case of the cheaper article, floorcloth. The process occupies weeks, and is carried on in warm air, to complete the oxidation of the oil and to turn out a thoroughly matured fabric for the floor. The net result, in the case of the most careful forms of manufacture, is that an article is produced which is not only extremely endurable but, in an increasing degree, artistic.

J. A. HUNTER

Formation of Strata. The Building of the Earth's Crust. The Modelling of Mountains. Geological Time and the Age of the World.

THE EARTH'S STORY IN THE ROCKS

THE history of the earth through uncounted ages is written in the stratified rocks. It is a most fascinating story, and there are few occupations which give the geologist greater pleasure than endeavouring to add a new chapter to it.

Thus, for instance, he finds that seams of coal generally rest upon strata of shale or clay, which are thickly filled with curious branching objects. A happy guess identified these as the roots of fossil trees, while we know that coal itself is the remains of vegetable matter which has lost nearly everything but its carbon. The inference is plain—that the layers of clay or shale represent the soil in which an ancient forest grew. At the same time we know that this clay or shale itself was once laid down at the bottom of a sea or lagoon, since it is arranged in layers such as we know to be due to the deposit of sediment by water, and often contains the fossil remains of marine or lacustrine organisms. But in many places, as we drive our shafts into the ground, we find one coal seam lying upon another with intermediate layers of clay or shale or sandstone, until the whole thickness of the coal measures may amount to many hundreds of feet. We can then reconstruct the history of this part of the earth's crust.

Fallen Forests. Once a sheet of water rested there, far below the present surface. Rivers brought down sediment which they had abraded from the distant hills, and spread it over the bottom of the lagoon or sea until the bed rose above the water, and became land dry enough for the growth of primeval forests. For centuries these forests grew and flourished, and loaded the ground with rich, carbonaceous products of their fallen trees or shrubs, until the ground again began to subside by the slow movement of the crust, and the water overflowed it once more. At the bottom of this new lake the trees fell and decayed, forming a carbonaceous bed ultimately to be converted into coal, which was again covered by the sediment brought down by new rivers. After the lapse of fresh ages the ground again emerged from the water, whether by the accumulation of river-borne sediment or by the actual elevation of the land by internal forces, a new forest grew up, and the wonderful cycle was repeated; and that not once, but perhaps a score of times, until a rich coalfield was stored up against the needs of twentieth-century man.

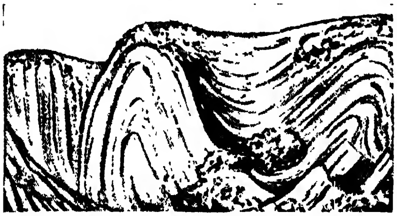
Almost every part of the earth's crust tells a story as interesting, though not always as clear as this. In the remaining portion of our course it will be our business to show, first, how the sedimentary rocks were moulded into the shape that gives character to the landscape; and second, how the history of the earth may be read in the innumerable strata which have been deposited by water and other agencies since the beginning of the world.

The Making of the Earth's Crust. The various agencies that have now been described account between them for the slow and painful architecture of the earth's crust. The landscape as we now behold it is the outcome of a balance between numerous and often conflicting causes. It has been moulded partly by the steady shrinking of the earth's crust and consequent production of wrinkles on the face of our aged planet, partly by the chiselling effect of the various agencies of denudation, and partly by the influence of life in all its forms, covering hill and valley with a veil of vegetation, and helping to break down the angular surface of the barren rock into the rounded contours of fertile soil so prevalent in a landscape.

By far the greater part of the visible surface of the earth's crust consists nowadays of stratified or sedimentary rocks, which, as we have seen, are derived by the work of various superficial agencies from the igneous rocks. Originally these sedimentary rocks were laid down, mostly on the beds of lakes or seas, by the action of water; a few also, like loess, by atmospheric action; and a few, like tuffs, by volcanic action. But the great majority of sedimentary rocks are of aqueous origin. They were originally laid down, therefore, in layers or strata of various thicknesses, which were roughly horizontal, whereas at the present day we find these strata arranged in the most varied and irregular manner. [See plate facing page 18.9.]

Incline of Strata. One may almost say that it is comparatively rare nowadays to find the strata lying parallel to the surface of the earth. A moment's thought will show us that if the strata still lay horizontally, the whole surface of the earth, or, at any rate, of a large area such as a continent, would be covered with a single uniform layer of one kind of rock. But we know that the case is very different. A glance at the geological map of the British Islands [see frontispiece to volume, coloured in accordance with the presence of the different kinds of rock] will show that it is far more complicated than any political map of the world. Within the compass of a single day's work the geologist traverses a score of different rock surfaces. What this means, of course, is that, instead of the strata continuing to lie horizontally, they have been tilted, so that the surface of the earth consists in great part not of their flat upper surfaces, but of their *outcropping* ends.

Succession of Strata. The student may familiarise himself with this statement by taking a number of different coloured papers or pieces of cloth, and laying them on the top of one another. If this packet be laid flat, it will represent the mode and position in which the various strata were laid down on the bed of the ancient sea. Each bed or layer of rock is distinct from the one beneath it, although they may all be composed of similar materials. We may, for instance, have a series of layers of sandstone, or an alternation of sandstone with shale, or an intermingling of organic strata such as coal seams, or a still more complicated mixture of strata.



63. THE CONTORTION OF STRATA

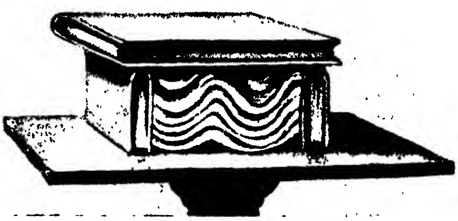
Each bed or stratum corresponds to a definite portion of time in the development of geological history, during which a certain kind of debris or loose material was being laid down, afterwards to be consolidated into comparatively hard rock. While the strata remain in their original position, only the one on the top, which, of course, was the last to be laid down, is visible. It is only by boring through the mass, as in sinking a well or coal pit, or in making a railway cutting, or when a natural section is made by a river cutting its gorge, or the sea undermining a cliff, that we learn the nature of the underlying strata. But it is evident that if we take our packet of sheets of paper and turn it on end, an observer looking from above will at once see the whole series of strata exhibited to his view. The same will be the case if, instead of turning the packet on end, we lay it on a sloping desk and, with a sharp knife, cut a horizontal section through it. On the flat surface thus produced the various sheets of paper, representing our typical strata of sedimentary rock, are exposed in the same order as that in which a vertical shaft would pass through them. This is what has actually happened in nature, and simplifies the task of the geologist.

The Strata Tilted. If it were not for the fact that the strata had thus been tilted in most parts of the earth, we should be confined for our knowledge of the earth's crust to such shallow scratches and borings as man is able to make. At the utmost we should know the nature of the crust to the depth of about a mile. But the fact that the strata have been tilted provides us with a far greater range of knowledge. For the denuding agencies which are ever at work on the earth's surface have done for the actual strata precisely what we have done with a sharp knife to our imaginary model. The contours or wrinkles on the earth's crust, which we saw to be a necessary consequence of the earth's cooling and contraction, have tilted the strata to very considerable angles [63]. We can see how this happens if we take a thickish paper-bound volume—a Christmas number of a magazine will do nicely—and, laying it flat on a table, press its edges towards one another. The result is that the middle of the book is elevated, whilst the separate leaves, which represent the strata of the crust, are thrown into a curved form [64], which, of course, means that they are tilted out of the horizontal into an arch.

Mountain Modelling. In this way the vast mountain range or tableland is formed—a wrinkle or swelling on the earth due to the contraction of the interior. The denuding agencies promptly get to work on this elevated region and gradually wear it down. If they were allowed to go on for an indefinite term, they would wear the whole surface down to the sea-level. But as even geological time is not infinite, these forces have succeeded only in wearing so much of the elevated part away as to leave what we now call a mountain range—such as the Alps—which is chiselled into the most wild and picturesque irregularities of shape simply because its materials were not homogeneous but of varying degrees of hardness, and consequently one part has been worn away faster than another.

The details of mountain carving are outside the necessarily limited scope of this course, but they may be studied with the greatest interest in more elaborate textbooks, such as Sir Archibald Geikie's "Scenery of Scotland." We need simply point out that the history of all mountainous districts is one of general elevation of the surface followed by the long secular process of modelling due to the various denuding agencies. It may be compared to the work of children making a snowman, who first heap up a roughly spherical accumulation of snow, and then shape it by scraping away the unnecessary parts.

Remnants of Ancient Mountains. Thus, our present mountain-chains, imposing as they are, do but represent the worn and wasted remnants of the huge elevations of earlier times.



64. THE FOLDING OF STRATA

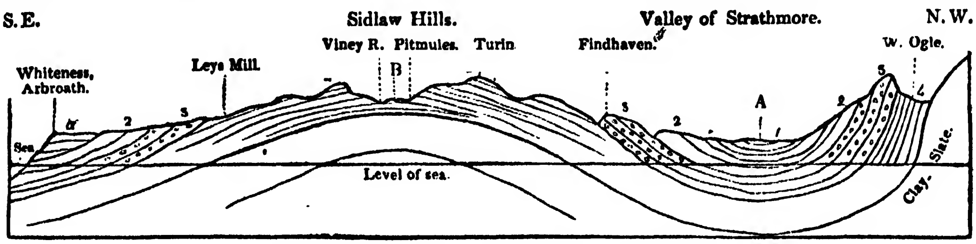
This process has occurred not once but scores of times in the history of the earth, and the present configuration of its surface is only the last term in a vast series. Again and again vast regions have been elevated and carved away by the denuding agencies till they fell so low that the sea overflowed them. Again they were elevated high above the sea-level, and again carved down, and this process has in some instances

been repeated to our actual knowledge five or six times at least.

The "Everlasting" Hills. We may infer that this movement has taken place far oftener. If we think of the slow changes which now occur among the "everlasting hills," which are practically the same to-day as they were when Homer sang and Rome was represented by only a few poor huts, we shall get some notion of the vast and almost unimaginable ages which have elapsed since the earth cooled down sufficiently to develop the seas and watercourses which have been the chief agents in this work. Yet it is probable that even this incalculable space of time is but the smaller part of the æons which have passed away since the whole solar system existed in the condition of a fiery nebula. That nebula itself may, according to a very probable hypothesis, have been the product of an earlier collision between two stars, each of which may have had its attendant planets as far advanced in the order of evolution as the earth is now. Science is impotent to do more than adumbrate such a possibility as this, the serious contemplation of which overwhelms the mind with the sense of its own insignificance.

expect to be the case, since we know that they were originally laid down on a roughly horizontal sea-bed. Sometimes, however, instead of being regularly tilted they have been crumpled into all kinds of bewildering curves, in which case they are spoken of as being *contorted* [63].

Arches and Troughs. The most common way in which strata have been tilted is that illustrated by the experiment with a magazine described above, where pressure from either end of the strata has raised them into a wide arch. In that case the strata at the two ends of the arch will be found to slope in opposite directions [65], while as we travel from one end of the arch or dome to the centre, we find that the dip of the strata is steadily diminishing, until at the centre it is reduced to zero and the strata there are horizontal. If we go further on the dip is reversed in direction and steadily increases. The surface of the ground in many places has been changed by the pressure consequent on the earth's internal contraction into a series of *arches*, which must clearly be divided by corresponding *troughs*, very much like the surface of the sea. In a trough it is clear that the changes in the dip of the strata



65 THE TROUGHS AND ARCHES OF STRATIFICATION

Dip of Strata. The past history of the earth, so far as geology can read it, is written in the strata of the sedimentary rocks. We can study these at our convenience, owing to the already explained fact that in most cases they have been tilted so that their ends, chiselled off by the sub-aerial denuding agencies, reach the surface, where we can study them at our leisure. These outcrops form, as it were, pages in the great book of the geological record. They are numbered consecutively, so that we know the order in which to study them, the upper ones being the later.

When we find a stratum or bed cropping out on the surface, the first thing that we have to do after finding out of what kind of rock it is composed is to see what angle it makes with the horizontal. This angle is called the *dip* of the strata, and it is measured by a simple instrument known as the *clinometer* [see page 719], which consists of a graduated semicircle with a pendulum pivoted on its centre. Whenever we are able, as in a railway cutting or a quarry, to see the strata in section, we can measure their dip by holding the diameter of our semicircle parallel to a bedding plane, and noting at what division on the scale the pendulum then hangs. As a rule the angle which the beds thus form with the horizontal is fairly constant, as we should

will be just the opposite to those in an arch. When the strata dip away from a central axis so as to form an arch, the structure is called an *anticline;* when they dip towards the central line so as to form a trough it is called a *syncline.*

Broken Arches. We seldom find this complete structure now in existence, since the arch has usually been worn away and the trough has been filled up by the processes of denudation and reconstruction which are always going forward. But we can reconstruct it in imagination by studying the dip of the strata. Where at two points some distance apart we find beds of a similar rock cropping out on the surface of the ground, pointing upwards and towards one another, we see without hesitation that they once met each other in a vast dome or saddle; if the dip of the strata be downward and each side towards the other, we infer that they actually meet at a point far below the surface. This curved arrangement of the strata characterises the greater part of superficial sedimentary rocks. In many places the curvature is more complicated and irregular; the strata have been so contorted, as in many parts of the Alps, that they are actually *inverted*, or bent round so that one part of the same stratum lies vertically upon another. But all these more complicated

forms of curvature are due to the same cause, the bending of the originally horizontal strata under lateral pressure.

Outcrop and Strike. The part of a tilted stratum which emerges at the present surface of the ground is called its *outcrop.* Where the stratum is of considerable width, this outcrop forms a long streak, the direction of which is known as the *strike.* The strike is obviously at right angles to the direction of dip. The width of the outcrop depends upon the thickness of the stratum and its inclination to the horizontal, since the outcrop is a section cut through the stratum by a horizontal plane. It may be only a few inches in width, or it may be many hundreds of feet. In the latter case it is usually found that the stratum, though composed of the same rock throughout, is divided by a number of fissure planes into a series of thinner strata, or *laminæ,* each of which corresponds to a definite period of the time when the materials of the rocks were being deposited.

The Order of the Strata. One of the most important things to study in connection with the sedimentary strata is the order in which they were deposited. In the rare cases where the strata still preserve their original horizontal attitude, the lowest stratum must clearly be the oldest, and the uppermost one the most recently deposited. If the strata have been tilted or crumpled [66] they still preserve the same relative chronological order. In order to find out from a series of strata cropping out on the surface of the earth which was originally the lowest, we have simply to measure the direction of their dip. Obviously, the stratum which has its outcrop farthest in that direction was originally the uppermost and is, therefore, the youngest. As we walk in the opposite direction we are tracing the strata backwards in time.

In this way we are enabled to say with entire certainty what was the order in which certain sedimentary rocks found in juxtaposition to one another were laid down ; and geologists have been able to establish a definite and coherent history of the earth, which it will be our business to describe in the concluding section of this course. We have already seen that the great majority of the sedimentary rocks contain fossils. These remains of prehistoric creatures differ widely in character and species, according to the rocks in which they are found. This fact has been of the greatest service to the study of the evolution of life, since the geologist is able to tell the biologist that certain rocks have invariably been laid down after certain others, and, consequently, that the fossils found in the latter were the ancestors, or at least the forerunners, of those associated with the former.

Geological Time. There is, unfortunately, no absolutely certain method of translating the geological scheme of time into the terms of human chronology. We can say with entire certainty that one stratum or set of rocks has been laid down before another, but we can only make rough guesses at the actual lapse of time which separates these events. Some inference may be drawn from the rate at which we see certain kinds of rock, such as shale or sandstone, being laid down at the present day. But it is very dangerous to argue that the same rate existed in the remote past. What we can be sure of is that the lapse of time represented by the formation of the sedimentary rocks was very great. To take a single instance, the carboniferous limestones of Western Europe are composed entirely of the shells and skeletons of minute organisms which lived in a long vanished sea, and strewed their calcareous remains on its bed when they died and sank down through the water. This process went on long enough to accumulate thousands of feet of limestone ; and at the very lowest estimate, that must have taken many thousands of years ; yet this is but one layer out of the immense thickness of sedimentary rocks which have been gradually accumulated in the upper part of the earth's crust. The geologist is probably well within the mark when he demands anything from one hundred to five hundred millions of years for the slow unfolding of the earth's physical history.

Joints. The sedimentary rocks are not only characterised by the roughly horizontal divisions into strata, but by vertical fissures or planes of division, which are known as *joints.* These are probably due to the strain which has been brought to bear upon these rocks in the course of the shrinkage of the earth's crust. Experiment has shown that the folding or twisting of the rocks gives rise to joints, just as the strain put on the ice of a glacier by its movement makes it crack into numerous crevasses. Igneous rocks present a jointed structure as well as stratified rocks, in consequence of the same cause. The existence of these joints has a two-fold importance to man. In the first place, they provide channels for the circulation of underground water, which travels along these cracks in an

66. TILTED STRATA

otherwise impermeable rock, and thus is enabled to contribute to those widespread subterranean effects which have already been described, and also to return to the surface in the form of springs where the configuration of the ground permits of this. It is also by taking advantage of these joints that the miner and the quarryman are enabled to perform their work with a minimum of exertion.

Division Planes. Stratified rocks, like flagstone and sandstone, are divided into more or less rectangular blocks by the double set of division planes which intersect them—the bedding planes which divide strata horizontally, and the joints which are usually vertical. In this way large cubical blocks can be quarried without much difficulty by taking advantage of these natural divisions. An ordinary block of household coal illustrates both sets of planes very well. It is divided in

THE WEARING DOWN OF ALPINE STRATA

A WEATHER-WORN, JAGGED EDGE OF THE ALPS, 11,000 FEET ABOVE SEA-LEVEL

HOW WIND, RAIN, AND SNOW WEAR DOWN AN ALPINE RANGE — THE PANORAMIC VIEW FROM THE SUMMIT OF LA ROUSETTE, 10,700 FEET HIGH

one direction into comparatively fine laminæ, which have usually soft surfaces and soil the fingers; these are bedding planes, or planes of stratification, which were originally horizontal or parallel to the dip of the coal seam. At right angles to them will be found joints, along which the coal splits when struck with a poker; the face thus exposed is rough and bright, and does not soil the fingers. Good coal will usually split along these two faces into roughly cubical fragments. The picturesque cracks and castellated structures so often seen in sandstone and limestone districts are due to the splitting of the rocks by meteorological action along the lines of joints. Igneous rocks are traversed by one set of divisional planes only—the joints. Thus the quarrying of a rock like granite is attended with greater difficulties than that of the stratified rock, as it naturally tends to split only in one direction. The remarkable columnar structures of basalt as seen by tourists in the Giant's Causeway and the Caves of Staffa are due to jointing.

67. THE TILTING OF STRATA AS SEEN ON THE COAST OF CORNWALL

Cleavage Planes. *Cleavage planes,* which we have already described as occurring in minerals, are a third set of divisional planes which have been induced by severe and long-continued pressure in certain rocks. It is most perfectly seen in slates, which can be readily split into thin plates along the cleavage planes. Some igneous rocks like the felsites show well-marked cleavage planes, which enable them to be split up into flags for paving.

There is another kind of division in rocks which has been caused by movements of the crust. This is known as a *dislocation,* which is simply a fracture extending for some distance through a mass of rock. Where the dislocation consists of a simple crack in the rock it is known as a *fissure.* But in the majority of cases the fracture has been accompanied by a vertical displacement of the rocks on one side of it, and it is then known as a *fault* [see page 2481]. Where the fault occurs in stratified rocks, the strata on one side of it no longer conform to those on the other. They have been moved bodily up or down, and the result is that they no longer join on to one another.

"Faults" and Earthquakes. Faults of this kind usually lead to weakening of the crust where they occur, and often play an important part in the occurrence of earthquakes or volcanic action. The reason why the district of Comrie is peculiarly subjected to earthquakes is that it lies upon the great fault of Perthshire. Faults are very important to miners, because where one occurs the coal seam or vein of metallic ore seems to come to a sudden end. As a matter of fact, it has been shifted bodily up or down, and some geological knowledge is necessary in order that the miner may know where to look for its continuance. A fault may be a vertical dislocation, but it is usually inclined. Its inclination from the vertical is known as the *hade,* and the amount of vertical displacement of the strata on either side is known as the *throw.* In the case of the vertical fault there is no lateral displacement of the strata, but if the fault be inclined it will be seen that the lateral displacement may be very considerable, and its extent depends both on the throw and the hade. The strata on each side of the fault preserve their relative positions; and when the hade and the throw are both known, it is an easy matter to find the lost seam or vein.

W. E. GARRETT FISHER

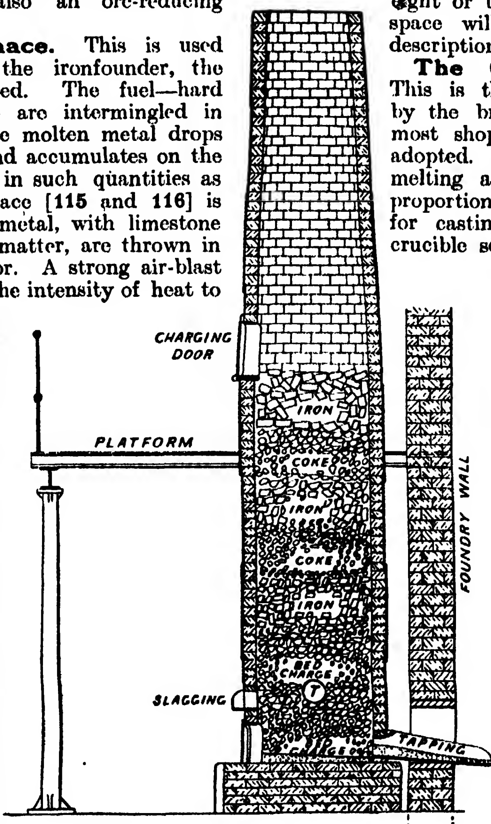
Various Types of Foundry Furnaces. Their Construction and Working. Ladles used in Foundry Practice.

FOUNDRY SMELTING

Metal Melting for Casting. The melting of metals and alloys for foundry use must not be confounded with the reduction of metals from their ores, with which the founder is not concerned, with the exception of steel made by the open hearth process, which is reduced and poured at once. Even with this, however, scrap steel is generally remelted. Another slight exception occurs in the successful casting of tunnel linings, segments, etc., direct from the blast furnace. But it remains true substantially that all foundry moulds are poured from metal or alloy that has been remelted for the purpose, and frequently more than once. Only by doing so can homogeneity be assured, and grading of different qualities be obtained.

The foundry furnaces used for remelting are divisible under five main heads—the cupola, the crucible, the reverberatory, the converter, and the open hearth, though the last-named, as already remarked, is also an ore-reducing furnace.

The Cupola Furnace. This is used almost exclusively by the ironfounder, the Bessemer cupola excepted. The fuel—hard coke—and pig or scrap are intermingled in successive layers, and the molten metal drops down through the fuel and accumulates on the bed, whence it is tapped in such quantities as are required. The furnace [115 and 116] is tall, and the coke and metal, with limestone flux for removing earthy matter, are thrown in through the charging door. A strong air-blast is necessary to produce the intensity of heat to melt the iron. There are different ways of directing this into the furnace. Sometimes it is done by encircling the zone of greatest fusion with a belt, through and from which the blast is distributed through a number of tuyere holes, as in 116, and this is the better plan. The other is to have two or three bent tuyere pipes arranged equidistantly around the zone, as in 115, T being one of the tuyere holes. The metal is either tapped directly into a ladle for pouring, or into an intermediate receiver as in 116. Different grades of metal can be melted at the same time by taking advantage of the separation effected by the alternate layers of coke and iron charged.



115. COMMON CUPOLA FURNACE

Economy in Working. Economy in the consumption of coke used in melting is ensured by the observance of a number of conditions. A short melting is inevitably wasteful, hence a blow of from four to six hours is better than one of two or three hours. In many foundries the cupolas are melting from soon after breakfast up till five or six o'clock. Large cupolas and large volumes of metal are better than the opposite conditions. Good coke is most important; so is an ample volume of blast. Other conditions are a good height of furnace, a deep bed-charge, careful charging, frequent slagging, and melting hot.

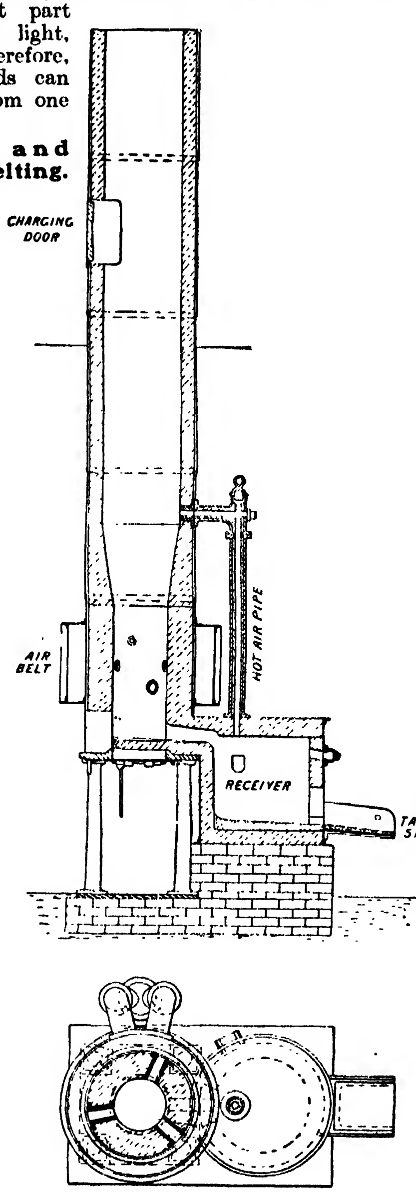
The furnace is built of sheet iron lined with firebrick, and daubed with sand around the lower areas. One of the best modern cupolas is the Thwaites, illustrated in 116. There are eight or ten successful types, but space will not permit of their description.

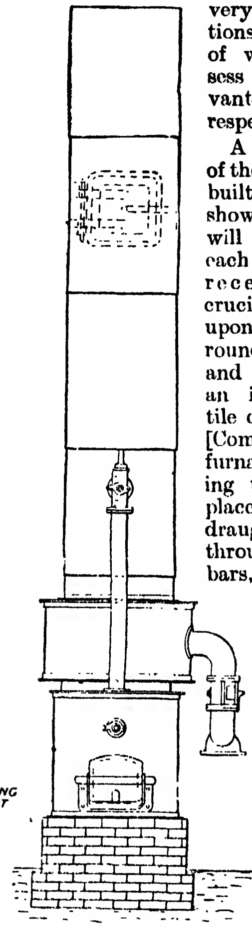
The Crucible Furnace. This is the furnace mostly used by the brassfounder—in fact, in most shops it is the only type adopted. It is also used for melting aluminium and a large proportion of the steel employed for casting. Although a single crucible seldom holds more than a hundredweight of alloy, and must carry rather less than that, yet castings of almost any dimensions are made from them by pouring the contents of a number of crucibles into the mould. This has never been done anywhere on so large a scale as at Krupp's, at Essen, where for many years nothing but crucibles were used for casting the biggest guns. The story has often been told of the hundreds of crucibles of metal all in readiness for the word of command, when they were poured out by the men with military precision. But in England the converter or open-hearth furnace

is used for heavy casts in steel, and the reverberatory furnace for those in brass and bronze alloys.

In most brass foundries a battery of furnaces is built [117], numbering from three or four to a dozen, and it is not infrequent for the contents of several to be requisitioned for one cast. But for the most part brasswork is light, and often, therefore, several moulds can be poured from one crucible.

Cupola and Crucible Melting. The reasons why iron is melted in a cupola, in contact with the fuel; and brass alloys, aluminium, and steel in crucibles, are as follows: Iron is much cheaper than the copper alloys and steel, and therefore a little waste is not of much importance. It is also generally required in larger quantities. But the principal reason is that iron is not injured by contact with the fuel, while the composition of the brasses and steels would be. It is difficult to maintain the purity of the two last named, the brasses because of the tendency of the metals having the lowest melting points, tin or zinc, to liquate, or volatilise, and so separate from the copper; the steels, because they depend for their qualities on the maintenance of exact and very minute proportions of carbon and other elements. It would therefore be impossible to maintain the compositions of the brasses and bronzes, or of the grade of any steel, if either were melted in contact with the fuel as iron is.





116 THWAITES CUPOLA FURNACE

Crucible furnaces [117] are built solidly of brick in the foundry floor, or they are of sheet iron or cast iron, brick-lined, and portable. The first are more suitable for the larger foundries, the second are often preferred in the smaller ones. There are very many variations in design, each of which may possess some slight advantage in some respect over others.

A small battery of the ordinary brick-built furnaces is shown in **117**. It will be seen that each furnace can receive but one crucible, which rests upon and is surrounded with coke, and covered with an iron plate and tile during melting. [Compare with Carr's furnace [**118**] showing the crucible in place.] Natural draught comes up through the grate-bars, and passes away through the chimney common to all the flues. The fire is dropped at night by pulling out the loose grate-bars, which are made of rods of square section. The ashes are taken away from the ash-pit into the ash-hole or gallery in front, the grating being lifted up for the purpose.

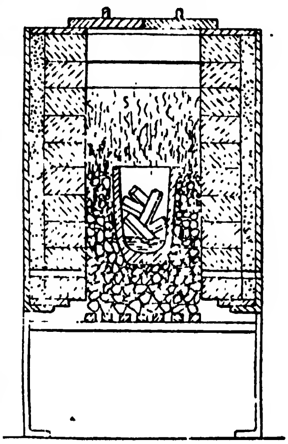
As a rule, the natural draught of a chimney is adopted for brass-melting furnaces, and coke is the fuel used. In recent years pressure blast has been applied to the Fletcher furnaces and others, and oil has been used as a fuel, as also has producer gas. It is probable that these will in course of time largely displace the old methods, because these agencies are more active, cleaner, and under better control.

Fig. **119** shows one of the Piat furnaces used largely in France. The actual furnace is made to tilt, so avoiding the pulling out of the crucible with tongs. In some of these, two crucibles are

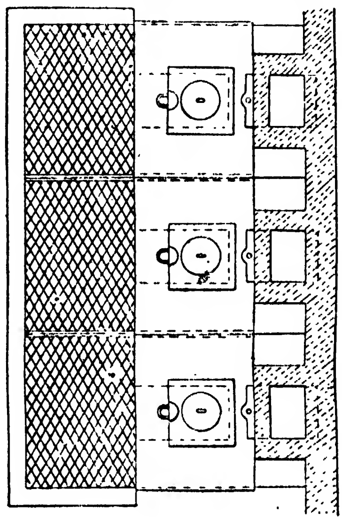
used, an upper one to warm the lumps of brass, and a lower one to melt them.

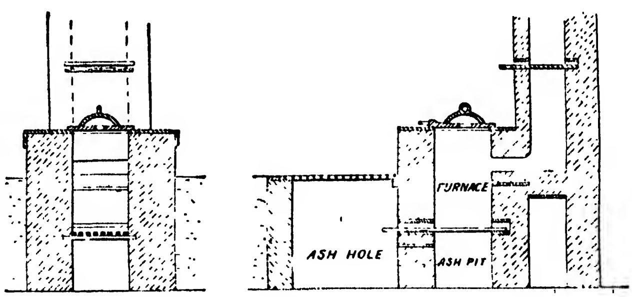
The Reverberatory Furnace. This and the brass-melting furnaces just described are often termed air furnaces, because they utilise natural chimney draught instead of pressure blast, like the cupolas and converters. The term "reverberatory" relates to the arched form of the furnace roof, which, being low, deflects the heat down on the metal that lies on the hearth.

Details of design vary, for these furnaces are used in nearly all metallurgical processes having for their object the reduction of various metals from their ores, or the remelting of metals and alloys. Essentially the furnace comprises a hearth on which the metal lies, and which is arched over by the roof; a fire-grate, separated from the hearth by a bridge of brick, and a tall chimney at the opposite end; and various openings in the furnace sides through which the operations going on are observed and controlled, and from which the metal is tapped. The flame and hot gases are drawn over the bridge and hearth by the chimney draught, and deflected by the roof on to the metal. The value of this type to the brass-founder lies in the fact that large masses can be melted without contamination with the fuel. The same remark applies to aluminium, and occasionally cast iron is so melted. The largest quantity of steel made is produced in furnaces of this type.



118. CARR'S CRUCIBLE FURNACE





117. BATTERY OF CRUCIBLE FURNACES

The Bessemer Converter. This is used for one particular grade of steel, used largely for castings, and for rolled products [see pages 925, 1013, 1044]. It is a remelting furnace, the pig having been previously smelted from the ore elsewhere in a blast furnace, and remelted in a cupola before it is introduced to the converter. The pig is decarbonised by the blowing of atmospheric air through the molten metal for about twenty minutes, and any excess of sulphur and phosphorus is removed, after which it is recarbonised by the addition of speigeleisen, or ferro-manganese (alloys of iron with carbon and manganese). It is then ready to be poured into the moulds. These converters deal with large and small quantities of steel, and divide favour with the open-hearth furnaces.

The Open-hearth Furnace. This is a reverberatory furnace designed with the special object of making mild steel from ore and pig or scrap. The ore and metal are decarbonised, not by a blast of air, as in the converter, but by the action of reducing agents—*fettling*. The metal is recarbonised by the addition of speigel, or ferro, and is then ready to be poured into castings.

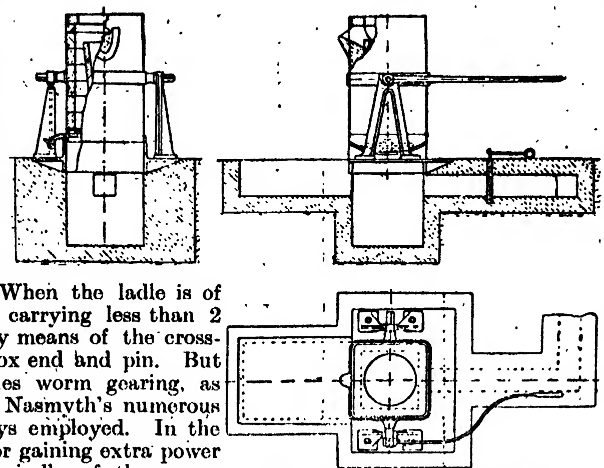
Foundry Ladles. In ordinary foundry work all metal is transferred from the cupola to the ladles before being poured into the moulds. These ladles vary in almost every respect one from another, from the small hand ladles, holding ½ cwt. to those carrying as much as 70 tons. The smallest is a hand ladle, usually made of cast iron, and furnished with one shank or handle. It is used for very light casts, and for supplying small quantities of metal required for feeding, etc. The form of ladle which is used more than any other in ordinary foundry work is the double-shank type, made in sizes holding from 1 to 3, 4 or 6 cwt. It is of sheet steel, riveted together, and is embraced by the ring into which it drops, and manipulated by the shank handle. Two, three, or four men are required for carrying it, according to its weight With 1 cwt. or 1½ cwt. of metal two men suffice. With 2 cwt. or 2½ cwt. three men are required. Above this load four men carry, two at the double handle, and two at a cross-bar supporting the single handle. During carriage the heat of the metal is prevented from scorching the men's faces by a cover of sheet iron placed over it. The metal is poured by the man or men at the

cross-handle tipping it sufficiently high. Ladles of the same type, but carrying from 3 or 4 cwt. up to ¾ ton, are slung in the crane and tipped by men at cross-handles.

Heavy Ladles. Above this size, and up to 12 tons, ladles of the type of 120 are used. These are made of boiler-plate riveted together, and according to their size the arrangements for pouring are modified. In any case, the ladle is slung in the crane by means of a strong crosshead and eye; from the ends of the crosshead depend slings with eyes which embrace the trunnions projecting from a belt encircling the ladles about the centre. When the ladle is of moderate size, say, carrying less than 2 tons, it is tipped by means of the cross-handle having a box end and pin. But in the heavier ladles worm gearing, as shown in 120 (one of Nasmyth's numerous inventions), is always employed. In the figure bevel gears for gaining extra power are added. The spindle of the worm is usually prolonged and drawn down rectangular in form to receive the cross-handle, by which its rotation is effected. Or, as in 120, the cross-handle is put on the shaft of the first bevel wheel. The task of tipping, owing to the enormous gain in power obtained by this gearing, is comparatively easy, one man easily regulating the flow of several tons of metal. A forked bar is used for pulling round and guiding the ladle while slung in the crane.

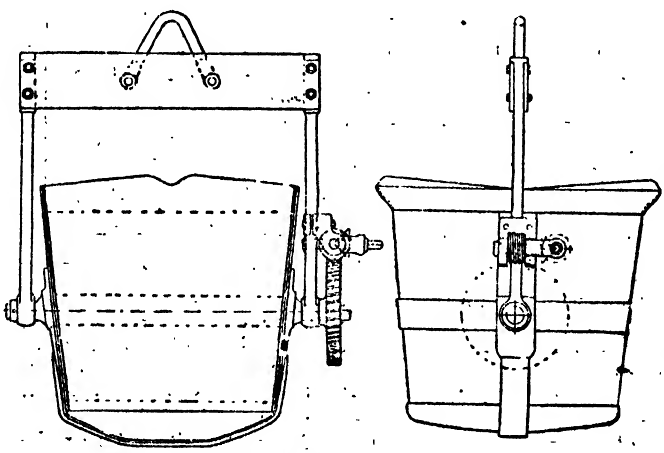
The carriage form of ladle is employed for large quantities of steel, avoiding the use of a crane, the ladle being pivoted in bearings in a heavy carriage. Loads of molten metal up to 70 tons are handled thus.

Lining Ladles. A part of the duties of the furnace-man consists in lining the ladles in readiness to receive the metal. Clay wash is smeared over the interior, and afterwards a coat of sand and blackening, or of loam and blackening; then the ladles are dried, the smaller by being laid face downwards over a coke fire, the larger by having a fire of sticks lit inside them. After the casting is done, the remaining metal, if not required for other work, is poured out into a gutter dug in the foundry floor, to be broken up after cooling. On the following morning the skulls, or thin linings of metal left adhering to the sides of the ladles, are knocked out, and they are relined for the next casting. One coating does not suffice for more than the casting of a single day.



119. PIAT CRUCIBLE FURNACE

Skimming Ladles. Several special forms of ladle have been devised with a view to the better skimming of the metal, but the old form of baying the scoriæ back with a skimmer bar still holds its own. For casting steel the goose-neck ladle is generally used—that is, the metal is run through a hole in the bottom of the ladle, the hole being opened by a goose-neck or bent lever lifting a plug which closes the hole when not pouring. Another ladle has a partition passing down inside the ladle near to the bottom, which effectually keeps back the dross. Another on the same principle has two spouts on opposite sides. The trouble of skimming is not so serious as some may think, for with a skimmer held firmly across a ladle's mouth it is very rare for any large amount of dross to flow over.



120. GEARED LADLE

Two typical foundry interiors are shown in 121 and 122. Fig. 121 includes a jib crane of the usual type, which covers the floor area within its range, piles of boxes being also seen. A larger building is illustrated in 122, having the floor covered with overhead electric travellers for handling metal and large moulding and castings. It will be observed that on the left wall, jib cranes are provided, for use while the travellers are busy in other directions.

JOSEPH G. HORNER

121. INTERIOR OF IRON FOUNDRY, WITH JIB CRANES

122. INTERIOR OF TYPICAL IRON FOUNDRY, WITH OVERHEAD TRAVELLERS AND WALL JIB CRANES

Spanish: The Tenses of the Subjunctive. The Passive Voice. French: The Verb. German: Comparison of Adjectives. Numerals.

SPANISH

Continued from page 1900

By José Plá Cárceles, B.A.

Use of the Tenses of the Subjunctive. The tense of the subjunctive mood to be used when translating into Spanish the subordinate clause of a compound phrase is generally determined by the tense employed in the principal clause. Thus:

(1) If the leading verb is in the present or future indicative, the present or compound past of the subjunctive (according to the original sentence) should be employed.—*probablemente le aconsejarán á Vd. que les escriba lo antes posible*, they will probably advise you to write to them as soon as possible; *me alegro de que haya venido Vd.*, I am glad you have come.

(2) If the principal verb is in the compound past or compound future of the indicative, the verb of the dependent clause should be conjugated in the present of the subjunctive.—*el gerente le ha ordenado que los envie inmediatamente*, the manager has ordered him to send them at once; *ya le habrán ordenado que regrese á Londres*, they will have already ordered him to return to London.

(3) If the verb in the principal sentence is in the past indicative or conditional, the second verb should be employed in the imperfect subjunctive.—*no le permitimos que saliese*, we did not permit him to go out; *temía que no llegara á tiempo*, I was afraid he might not arrive in time; *me habían aconsejado que lo aceptase*, they had advised me to accept it; *le hablaría si lo conociese*, I should speak to him if I knew him.

(4) When the first verb is in the imperfect subjunctive preceded by the conjunction *si*, the subordinate verb must be employed in the conditional.—*si lo vendiera lo compraría*, should he sell it, I should buy it.

(5) If the leading verb is in the pluperfect subjunctive, the second verb must be conjugated in the same tense.—*si lo hubiera sabido yo tambien hubiera ido*, had I known it, I should also have gone.

The student need not learn the use of the future subjunctive, as this tense is very seldom met with in literature, and never in ordinary conversation. It can almost always be substituted by another tense without any essential alteration in the meaning of the sentence.

EXERCISE XL

a term	*un plazo*	postcard	*postal*
to request	*rogar*	the parcel	*el paquete*
disengaged	*desocupado*	to call	*llamar*
to come down	*bajar*		
the mistake	*la equivocación*		
to let one know	*avisar*		
to keep one's word	*cumplir la palabra*		

1. We shall not pay unless you give us the receipt. 2. Please send me a telegram as soon as you receive the parcels. 3. The cashier will check the books again so that there may be no mistakes. 4. They will not sign the contract, although they have promised to do so (*hacerlo*). 5. It it a pity he has not come today. 6. If he asks for me, tell him to wait at (*en*) the station. 7. Let me know when she comes down. 8. She will not learn it unless it is very easy. 9. At what time do you want us to call you? 10. Please call me at seven o'clock sharp. 11. If they were in London I should pay them a visit. 12. I think your friends will arrive before we finish the letter. 13. I doubt whether they will keep their word. 14. We should rent that house if it were not so expensive. 15. Will it be necessary (for) me to take another ticket there? 16. I think it would be better if you took a return ticket at this station. 17. I should like (*me gustaría*) to know his new address. 18. It is possible that they do not speak Spanish. 19. I will explain it to you when I have more time. 20. I am very sorry (*siento mucho*) that she is so ill. 21. We request you to grant him a longer term. 22. We are sure he will pay as soon as you send him the invoice. 23. I should buy one if they were not so large. 24. We want you to give us your opinion. 25. Passengers are requested (*se ruega á los pasajeros*) not to smoke in the cabins. 26. Do you want me to change it? 27. I shall let you know when I am disengaged. 28. It was not necessary (for) them to reply at once. 29. Had they replied by return of post, we should have sold the goods at better prices. 30. Send me a postcard lest I should forget (it).

Passive Voice. The Spanish passive voice is formed, as in English, by placing the different tenses, single or compound, of the verb *ser* (to be) in front of the past participle of all transitive verbs. Thus, from the active verb *castigar* (to punish) the passive verb *ser castigado* (to be punished) is obtained.

In all passive sentences the past participle takes the gender and number of the substantive or substantives to which it refers.—*los prisioneros fueron canjeados al amanecer*, the prisoners were exchanged at daybreak. In compound tenses only the past participle of the transitive verb undergoes the change, that of the verb "to be" being unchangeable.—*las mejoras han sido realizadas sin grandes gastos*, the improvements have been carried out without great expense. In phrases of this kind the preposition "by" is generally translated *por*, unless the verb expresses an act of the mind, in which case it is often rendered by *de*.

As we have already seen [see page 2491], many impersonal sentences which in English are constructed in the passive voice must be translated into Spanish by the reflective form of the verb, a construction which is not so often used when the verb expresses a mental action and its object is a person.—*las vocales del idioma inglés no siempre se pronuncian del mismo modo*, the vowels of the English language are not always pronounced in the same manner; *en esa casa, el padre es mucho más respetado que la madre*, in that house the father is much more respected than the mother. *En esa casa se respeta mucho más al padre que á la madre* would also be correct.

EXERCISE XLI

to reward	*recompensar*	to praise	*elogiar*
to treat	*tratar*	to employ	*emplear*
to acclaim	*aclamar*	to avoid	*evitar*
to sentence	*sentenciar*	to improve	*mejorar*
to promote	*ascender*	to recognise	*reconocer*
to hate	*odiar*	to admire	*admirar*
to elect	*elegir*	to deserve	*merecer*
to legalise	*legalizar*	to forge	*falsificar*
to dismiss	*despedir*	to applaud	*aplaudir*
to defeat	*derrotar*	to amount	*ascender*
to belove	*amar*	the kindness	*la bondad*
the protest	*la protesta*	the minister	*el ministro*
a tenor	*un tenor*	the troop	*la tropa*
a war	*una guerra*	a marquis	*un marqués*
a picture	*un cuadro*	the owner	*el dueño*
the will	*el testamento*	a colony	*una colonia*
the service	*el servicio*	the coast	*la costa*
a casualty	*una baja*	a viceroy	*un virrey*
an Indian	*un indio*	municipal	*municipal*

the consideration	*la consideración*
the generosity	*la generosidad*
the behaviour	*la conducta*
to communicate	*comunicar*
the imprisonment	*la prisión*
the independence	*la independencia*
everybody	*todo el mundo*
cordially	*cordialmente*
silver mines	*minas de plata*
in due form	*en debida forma*
the authority	*la autoridad*
a forger	*un falsificador*
utterly	*completamente*
bloody	*sangriento*
revolutionary	*revolucionario*
both of them	*los dos*
a member of Parliament	*un diputado*
A provincial governor	*un gobernador de provincia*
in his progress through	*á su paso por*
an accomplished fact	*un hecho consumado*
South American republics	*Repúblicas Sud-Americanas*

1. They (fem.) have not been rewarded by the owners with as much generosity as they hoped. 2. His last picture was admired and praised by everybody. 3. The new members of Parliament were elected in the (*al*) following year. 4. The protest was signed by all the officials of the company. 5. She has not been treated with all the consideration and kindness (that) her behaviour deserves. 6. They would have been employed in the colonies. 7. All the Ministers were called to the palace. 8. The news was communicated by telegraph to all the provincial governors. 9. The documents were legalised in due form, so as to (*para*) avoid their being forged. 10. The king was acclaimed in his progress through the streets of the town. 11. The forgers of the first will were then sentenced to five years (*de*) imprisonment. 12. His sister will be dismissed one of these days. 13. I think the new authorities will be cordially received. 14. All the municipal services have been improved in the last ten months. 15. The tenor sang very well, and was very much applauded that night. 16. Both of them were promoted at the same time. 17. The revolutionary troops have been utterly defeated near the coast. 18. It is said that this battle has been the bloodiest of the whole war. The casualties of both sides amounted to 8000 men. 19. The independence of the South American republics was recognised by the United States as an accomplished fact in 1822. 20. The Marquis of Mancera, who had been appointed Viceroy of Peru in 1639, was as much beloved by the Indians as (he was) hated by the owners of the silver-mines, and feared by the enemies of Spain.

READING EXERCISE

El 7 de Junio es una fecha de cruenta recordación en los fastos de Jamaica, pues marca el día en que tuvo lugar el espantoso terremoto de 1692, en el cual perecieron más de dos mil personas. Manzanas enteras de casas, situadas en la parte de la capital contigua al puerto, desaparecieron bajo el rugiente mar, y muchos barrios populosos viéronse en un santiamén, reducidos á un informe montón de escombros. No se limitó el estrago á los arrabales de Port Royal, pues la isla toda experimentó los desastrosos efectos del cataclismo; moles ingentes se desgajaron de las montañas, y en muchos parajes abriéronse enormes grietas, que, al soldarse, sepultaron en las entrañas de la tierra caseríos enteros, desviando el curso de los ríos y haciendo brotar manantiales nuevos. El gran número de cadáveres insepultos, expuestos en las calles á la acción del calor intenso, que siguió á la catástrofe seísmica, ocasionó una horrible pestilencia, que produjo casi tanta mortandad como el mismo terremoto. Como si esto no fuera ya bastante, un nuevo azote se cernió sobre la malhadada isla; los piratas franceses cayeron sobre los puertos del norte.

TRANSLATION OF READING EXERCISE

June 7 is a date of fateful import in the annals of Jamaica, recalling as it does the terrible earthquake of 1692, in which more than two thousand persons perished. Whole blocks of houses in the capital lying near the port disappeared beneath the devouring waves, and many thickly populated quarters were reduced, with extraordinary suddenness, to shapeless heaps of débris. Nor was the havoc confined to the suburbs of Port Royal, for the whole of the island shared the disastrous effects of the cataclysm. Huge rocks were torn from the mountain sides; enormous clefts opened in many places on the surface of the island, and

whole hamlets were buried in the bowels of the earth as the chasms reclosed. Rivers forsook their old courses, and new springs gushed from the disturbed surface of the island. In the city hundreds of corpses lying unburied in the streets, exposed to the intense heat which followed in the wake of the convulsions, gave rise to a horrible pestilence, which claimed as many victims as the earthquake itself. As though these misfortunes were not sufficient, a fresh plague fell upon the stricken island; for the French pirates attacked the northern ports.

KEY TO EXERCISE XXXVII (PAGE 2763)

1. cambie, cambies, cambie, cambiemos, cambieis, cambien. 2. cosa, cosas, cosa, cosamos, cosais, cosan. 3. viva, vivas, viva, vivamos, vivais, vivan. 4. venda, vendas, venda, vendamos, vendais, vendan. 5. alquile, alquiles, alquile, alquilemos, alquileis, alquilen. 6. haya, hayas, haya, hayamos, hayais, hayan. 7. escriba, escribas, escriba, escribamos, escribais, escriban. 8. sea, seas, sea, seamos, seais, sean. 9. conteste, contestes, conteste, contestemos, contesteis, contesten. 10. coma, comas, coma, comamos, comais, coman.

KEY TO EXERCISE XXXVIII (PAGE 2899)

1. entregara, entregaras, entregara, entregáramos, entregárais, entregaran. 2. aprendiese, aprendieses, aprendiese, aprendiésemos, aprendiéseis, aprendiesen. 3. embarcara, embarcaras, embarcara, embarcáramos, embarcárais, embarcaran. 4. cancelase, cancelases, cancelase, cancelásemos, canceláseis, cancelasen. 5. emitiera, emitieras, emitiera, emitiéramos, emitiérais, emitieran. 6. escribiese, escribieses, escribiese, escribiésemos, escribiéseis, escribiesen. 7. fuera, fueras, fuera, fuéramos, fuérais, fueran. 8. temiese, temieses, temiese, temiésemos, temiéseis, temiesen.

KEY TO EXERCISE XXXIX

1. esté, estés, esté, estemos, esteis, estén. 2. cantare, cantares, cantare, cantáremos, cantáreis, cantaren. 3. perdiera *or* perdiese, perdieras *or* perdieses, perdiera *or* perdiese, perdiéramos *or* perdiésemos, perdiérais *or* perdiéseis, perdieran *or* perdiesen. 4. prometiere, prometieres, prometiere, prometiéremos, prometiéreis, prometieren. 5. haya, hayas, haya, hayamos, hayais, hayan. 6. viajase, viajases, viajase, viajásemos, viajáseis, viajasen. 7. discutiere, discutieres, discutiere, discutiéremos, discutiéreis, discutieren. 8. surtiera, surtieras, surtiera, surtiéramos, surtiérais, surtieran. 9. responda, respondas, responda, respondamos, respondais, respondan. 10. firmare, firmares, firmare, firmáremos, firmáreis, firmaren.

Continued

FRENCH

Continued from page 2904

By Louis A. Barbé, B.A.

Être, TO BE.

INDICATIVE.

Simple Tenses.

Present.

I am, etc.

je suis	*nous sommes*
tu es	*vous êtes*
il, elle est	*ils, elles sont*

Imperfect.

I was, etc.

j'étais	*nous étions*
tu étais	*vous étiez*
il, elle était	*ils, elles étaient*

Past Definite.

I was, etc.

je fus	*nous fûmes*
tu fus	*vous fûtes*
il, elle fut	*ils, elles furent*

Future.

I shall be, etc.

je serai	*nous serons*
tu seras	*vous serez*
il, elle sera	*ils, elles seront*

Compound Tenses.

Past Indefinite.

I have been, etc.

j'ai été	*nous avons été*
tu as été	*vous avez été*
il, elle a été	*ils, elles ont été*

Pluperfect.

I had been, etc.

j'avais été	*nous avions été*
tu avais été	*vous aviez été*
il, elle avait été	*ils, elles avaient été*

Past Anterior.

I had been, etc.

j'eus été	*nous eûmes été*
tu eus été	*vous eûtes été*
il, elle eut été	*ils, elles eurent été*

Future Anterior.

I shall have been, etc.

j'aurai été	*nous aurons été*
tu auras été	*vous aurez été*
il, elle aura été	*ils, elles auront été*

CONDITIONAL.

Present.

I should be, etc.

je serais	*nous serions*
tu serais	*vous seriez*
il, elle serait	*ils, elles seraient*

Past.

I should have been, etc.

j'aurais été	*nous aurions été*
tu aurais été	*vous auriez été*
il, elle aurait été	*ils, elles auraient été*

IMPERATIVE.

Present.

sois, be (thou)
qu'il soit, qu'elle soit, let him be, let her be
soyons, let us be
soyez, be (ye)
qu'ils soient, qu'elles soient, let them be

SUBJUNCTIVE.

Present.

That I may be, etc.

que je sois	*que nous soyons*
que tu sois	*que vous soyez*
qu'il, qu'elle soit	*qu'ils, qu'elles soient*

Imperfect.

That I might be, etc.

que je fusse	*que nous fussions*
que tu fusses	*que vous fussiez*
qu'il, qu'elle fût	*qu'ils, qu'elles fussent*

Past.

That I may have been, etc.

que j'aie été	*que nous ayons été*
que tu aies été	*que vous ayez été*
qu'il, qu'elle ait été	*qu'ils, qu'elles aient été*

Pluperfect.

That I might have been, etc.

que j'eusse été	*que nous eussions été*
que tu eusses été	*que vous eussiez été*
qu'il, qu'elle eût été	*qu'ils, qu'elles eussent été*

INFINITIVE.

Present.	*Past.*
être, to be	*avoir été*, to have been

PARTICIPLE.

Present.

étant, being.

Past.

été, been; *ayant été*, having been.

REMARKS. 1. The past participle *été* is always invariable. *Être* is sometimes used impersonally instead of *y avoir*:

Il était un roi d'Yvetot, peu connu dans l'histoire, There was a king of Yvetot, little known in story.

Il était une fois un roi et une reine qui avaient un fils beau comme le jour, There were once a king and queen who had a son beautiful as the day.

2. *Être à*, followed by a noun or personal pronoun, means "to belong to."

Ce livre-ci est à moi, celui-là est à mon ami, This book belongs to me, that one belongs to my friend.

3. *Être à même de*, followed by an infinitive, means "to be able to," "to be in a position to": *Il est à même de nous aider*, He is in a position to help us.

4. *Être à*, followed by the active voice, is equivalent to the English construction in which "to be" is followed by a passive infinitive: *Il est à craindre*, He is to be feared; *vous êtes à plaindre*, You are to be pitied.

5. *Y être* is used idiomatically, sometimes with the meaning of "to be at home," sometimes with that of "to be ready," "to understand": *J'ai besoin de parler à votre frère; y est-il? Non, il n'y est pas*, I want to speak to your brother; is he at home? No, he is not at home.

Y êtes-vous? Oui, j'y suis, Are you ready? Yes, I am ready.

6. The expressions *être bien avec* and *être mal avec* mean "to be on good terms with," "to be on bad terms with": *Il est bien avec tout le monde*, He is on good terms with everybody.

7. "To be," referring to the state of health, is not rendered literally by *être*, but either by the reflexive verb *se porter*, to carry oneself, or by *aller*, to go: How are you? *Comment vous portez-vous?* or more usually *Comment allez-vous?*

8. "To be," is rendered by *valoir* in the expression "to be better (preferable)": It is better late than never, *Il vaut mieux tard que jamais*.

Ne pas Être, not to be.

INDICATIVE.

Present.	*Past Indefinite.*
je ne suis pas, etc.	*je n'ai pas été*
Imperfect.	*Pluperfect.*
je n'étais pas, etc.	*je n'avais pas été*
Past Definite.	*Past Anterior.*
je ne fus pas, etc.	*je n'eus pas été, etc.*
Future.	*Future Anterior.*
je ne serai pas, etc.	*je n'aurai pas été, etc.*

CONDITIONAL.

Present.	*Past.*
je ne serais pas, etc.	*je n'aurais pas été*

IMPERATIVE.

Present.

Ne sois pas
qu'il ne soit pas, qu'elle ne soit pas
Ne soyons pas
Ne soyez pas
qu'ils ne soient pas, qu'elles ne soient pas

SUBJUNCTIVE.

Present.	*Past.*
que je ne sois pas, etc.	*que je n'aie pas été, etc.*
Imperfect.	*Pluperfect.*
que je ne fusse pas, etc.	*que je n'eusse pas été, etc.*

INFINITIVE.

Present.	*Past.*
ne pas être	*ne pas avoir été*

PARTICIPLE.

Present.	*Past.*
n'étant pas	*n'ayant pas été*

Être, conjugated interrogatively.

INDICATIVE.

Present.	*Past Indefinite.*
suis-je?	*ai-je été?*
est-il, est-elle?	*a-t-il été, a-t-elle été?*
Imperfect.	*Pluperfect.*
étais-je?	*avais-je été?*
Past Definite.	*Past Anterior.*
fus-je?	*eus-je été?*
Future.	*Future Anterior.*
serai-je?	*aurai-je été?*

CONDITIONAL.

Present.	*Past.*
serais-je?	*aurais-je été?*

Être,

conjugated interrogatively and negatively.

INDICATIVE.

Present.	*Past Indefinite.*
ne suis-je pas?	*n'ai-je pas été?*
n'est-il pas?	*n'a-t-il pas été?*
n'est-elle pas?	*n'a-t-elle pas été?*
Imperfect.	*Pluperfect.*
n'étais-je pas?	*n'avais-je pas été?*
Past Definite.	*Past Anterior.*
ne fus-je pas?	*n'eus-je pas été?*
Future.	*Future Anterior.*
ne serai-je pas?	*n'aurai-je pas été?*
ne sera-t-il pas?	*n'aura-t-il pas été?*
ne sera-t-elle pas?	*n'aura-t-elle pas été?*

CONDITIONAL.

Present. *Past.*

ne serais-je pas ? *n'aurai-je pas été ?*

In English, a positive statement followed by the negative-interrogative form of "have," "be," or one of the modal auxiliaries "do," "can," "ought," "should," etc., is used to indicate that the answer "Yes" is expected. In French, the one expression *N'est-ce pas ?* is used, whatever be the auxiliary, the tense, or the person:

He is a friend of yours, is he not ? *C'est un de vos amis, n'est-ce pas ?*

You speak French, do you not ? *Vous parlez français, n'est-ce pas ?*

He wrote to you last week, did he not ? *Il vous a écrit la semaine dernière, n'est-ce pas ?*

They will be there, will they not ? *Ils y seront, n'est-ce pas ?*

EXERCISE XXII.

1. Whose books are those ? They are my brother's.
2. I wanted to speak to your father, but he was not in.
3. The ass is temperate (*sobre*) and patient ; it would be the handsomest of domestic animals if there were no horse.
4. The Gauls (*Gaulois*) were brave and strong (*robuste*).
5. Marshal Lannes had been (a) dyer ; Marshal Ney was a cooper before being (to be) (a) soldier.
6. The father of the philosopher (*philosophe*) Diderot, and that of the historian (*historien*) Rollin were cutlers (*couteliers*).
7. Pardon is better than revenge (*la vengeance*).
8. The Romans (*Romains*) were the masters of the world (*le monde*).
9. There were once two men who were very poor and very wretched (*malheureux*).
10. The first was blind (*aveugle*) from his birth (*de naissance*) ; the second was paralysed.
11. They were both incapable of doing (*faire*) anything.
12. The blind (man), who was strong, carried (*porta*) the paralytic (*paralytique*).
13. The paralytic, who was endowed (*doué*) with (a) good sight (*la vue*), guided (*dirigea*) his companion.
14. Alone they would have (*être*) died (*morts*) of hunger.
15. United (*unis*) they were able to gain their living (*vie*).

Regular Verbs

1. There are four conjugations, distinguished from each other by the ending of the infinitive.
2. The infinitive of the first conjugation ends in *er*, as *donner*, to give.
3. The infinitive of the second conjugation ends in *ir*, as *finir*, to finish.
4. The infinitive of the third conjugation ends in *oir*, as *recevoir*, to receive.
5. The infinitive of the fourth conjugation ends in *re*, as *vendre*, to sell.
6. Regular verbs are those of which all the tenses are formed uniformly from the primitive tenses, or principal parts.
7. The primitive tenses, or principal parts, are five: (*a*) *the present of the infinitive*, (*b*) *the present participle*, (*c*) *the past participle*, (*d*) *the present indicative*, and (*e*) *the past definite*.
8. For each of the conjugations the principal parts are as follow :

FIRST CONJUGATION : *donner, donnant, donné, je donne, je donnai.*

SECOND CONJUGATION : *finir, finissant, fini, je finis, je finis.*

THIRD CONJUGATION : *recevoir, recevant, reçu, je reçois, je reçus.*

FOURTH CONJUGATION : *vendre, vendant, vendu, je vends, je vendis.*

I. From the *present of the infinitive* are formed: (*a*) the *future indicative*, and (*b*) the *present conditional* by changing *r* of the first and of the second conjugation, *oir* of the third conjugation, and *re* of the fourth conjugation into *rai, ras, ra, rons, rez, ront* for the *future*, and into *rais, rais, rait, rions, riez, raient* for the *conditional :*

DONNE-R	FINI-R
Future.	*Future.*
je donne-rai	*je fini-rai*
tu donne-ras	*tu fini-ras*
il donne-ra	*il fini-ra*
nous donne-rons	*nous fini-rons*
vous donne-rez	*vous fini-rez*
ils donne-ront	*ils fini-ront*
Conditional	*Conditional*
je donne-rais	*je fini-rais*
tu donne-rais	*tu fini-rais*
il donne-rait	*il fini-rait*
nous donne-rions	*nous fini-rions*
vous donne-riez	*vous fini-riez*
ils donne-raient	*ils fini-raient*
RECEV-OIR.	VEND-RE.
Future.	*Future.*
je recev-rai	*je vend-rai*
tu recev-ras	*tu vend-ras*
il recev-ra	*il vend-ra*
nous recev-rons	*nous vend-rons*
vous recev-rez	*vous vend-rez*
ils recev-ront	*ils vend-ront*
Conditional	*Conditional.*
je recev-rais	*je vend-rais*
tu recev-rais	*tu vend-rais*
il recev-rait	*il vend-rait*
nous recev-rions	*nous vend-rions*
vous recev-riez	*vous vend-riez*
ils recev-raient	*ils vend-raient*

EXCEPTIONS : 1. First Conjugation—*Aller*, to go ; future, *j'irai ;* conditional, *j'irais.*

Envoyer, to send ; future, *j'enverrai ;* conditional, *j'enverrais.*

2. Second Conjugation: *Acquérir*, to acquire ; future, *j'acquerrai ;* conditional, *j'acquerrais.*

Courir, to run ; future, *je courrai ;* conditional, *je courrais.*

Cueillir, to gather ; future, *je cueillerai ;* conditional, *je cueillerais.*

Mourir, to die ; future, *je mourrai ;* conditional, *je mourrais.*

Tenir, to hold ; future, *je tiendrai ;* conditional, *je tiendrais.*

Venir, to come ; future, *je viendrai ;* conditional, *je viendrais.*

3. Third Conjugation : *Asseoir*, to seat ; future, *j'assiérai ;* conditional, *j'assiérais.*

Avoir, to have; future, *j'aurai*; conditional, *j'aurais*.

Falloir, to be necessary; future, *il faudra*; conditional, *il faudrait*.

Savoir, to know; future, *je saurai*; conditional, *je saurais*.

Valoir, to be worth; future, *je vaudrai*; conditional, *je vaudrais*.

Voir, to see; future, *je verrai*; conditional, *je verrais*.

Vouloir, to wish; future, *je voudrai*; conditional, *je voudrais*.

4. Fourth conjugation: *Être*, to be; future, *je serai*; conditional, *je serais*.

Faire, to make; future, *je ferai*; conditional, *je ferais*.

II. From the Present Participle are formed (*a*) the three persons plural of the *Present Indicative*, by changing *ant* into *ons*, *ez*, *ent*; but the third person plural of the third conjugation has the further change of *e* into *oi* in the penultimate syllable:

Donn-ant	Finiss-ant
nous donn-ons	*nous finiss-ons*
vous donn-ez	*vous finiss-ez*
ils donn-en.	*ils finiss-ent*

Recev-ant	Rend-ant
nous recev-ons	*nous rend-ons*
vous recev-ez	*vous rend-ez*
ils (reçoiv-ent)	*ils rend-ent.*

Exceptions:

1. First Conjugation: *Allant*, going; *ils vont.*

2. Third Conjugation: *Ayant*, having; *nous avons, vous avez, ils ont.*

Sachant, knowing; *nous savons, vous savez, ils savent.*

3. Fourth Conjugation: *Étant*, being; *nous sommes, vous êtes, ils sont.*

Disant, saying; *vous dites.*

Faisant, making; *vous faites, ils font.*

(*b*) The Imperfect of the Indicative, by changing *ant* into *ais*, *ais*, *ait*, *ions*, *iez*, *aient*.

Donn-ant	Finiss-ant
je donn-ais	*je finiss-ais*
tu donn-ais	*tu finiss-ais*
il donn-ait	*il finiss-ait*
nous donn-ions	*nous finiss-ions*
vous donn-iez	*vous finiss-iez*
ils donn-aient	*ils finiss-aient*

Recev-ant	Vend-ant
je recev-ais	*je vend-ais*
tu recev-ais	*tu vend-ais*
il recev-ait	*il vend-ait*
nous recev-ions	*nous vend-ions*
vous recev-iez	*vous vend-iez*
ils recev-aient	*ils vend-aient*

Exceptions:

Third Conjugation: *Ayant*, having; *j'avais*, etc.; *sachant*, knowing; *je savais*, etc.

(*c*) The Present Subjunctive by changing *ant* into *e*, *es*, *e*, *ions*, *iez*, *ent*; but, in the third conjugation the three persons of the singular, and the third person plural require the further change of the *e* of the penultimate syllable into *oi*. The preceding *c* then takes a cedilla.

Donn-ant.	Finiss-ant
que je donn-e	*que je finiss-e*
que tu donn-es	*que tu finiss-es*
qu'il donn-e	*qu'il finiss-e*
que nous donn-ions	*que nous finiss-ions*
que vous donn-iez	*que vous finiss-iez*
qu'ils donn-ent	*qu'ils finiss-ent*

Recev-ant	Vend-ant
que je (reçoiv-e)	*que je vend-e*
que tu (reçoiv-es)	*que tu vend-es*
qu'il (reçoiv-e)	*qu'il vend-e*
que nous recev-ions	*que nous vend-ions*
que vous recev-iez	*que vous vend-iez*
qu'ils (reçoiv-ent)	*qu'ils vend-ent*

Exceptions:

1. First Conjugation: *Allant*, going; *que j'aille, que tu ailles, qu'il aille, qu'ils aillent.*

2. Second Conjugation: *acquérant*, acquiring; *que j'acquière, que tu acquières, qu'il acquière, qu'ils acquièrent.*

Mourant, dying; *que je meure, que tu meures, qu'il meure, qu'ils meurent.*

Tenant, holding; *que je tienne, que tu tiennes, qu'il tienne, qu'ils tiennent.*

Venant, coming; *que je vienne, que tu viennes, qu'il vienne, qu'ils viennent.*

3. Third Conjugation: *Fallant* (not used), it being necessary; *qu'il faille.*

Mouvant, moving; *que je meuve, que tu meuves, qu'il meuve, qu'ils meuvent.*

Pouvant, being able; *que je puisse, que tu puisses, qu'il puisse, que nous puissions, que vous puissiez, qu'ils puissent.*

Valant, being worth; *que je vaille, que tu vailles, qu'il vaille, qu'ils vaillent.*

Voulant, wishing; *que je veuille, que tu veuilles, qu'il veuille, qu'ils veuillent.*

4. Fourth Conjugation: *Étant*, being; *que je sois, que tu sois, qu'il soit, que nous soyons, que vous soyez, qu'ils soient.*

Buvant, drinking; *que je boive, que tu boives, qu'il boive, qu'ils boivent.*

Faisant, making; *que je fasse, que tu fasses, qu'il fasse, que nous fassions, que vous fassiez, qu'ils fassent.*

Only three verbs—*être* (to be), *pouvoir* (to be able), and *faire*, (to make) are irregular throughout the whole of the present subjunctive: *que je sois, que je puisse*, etc; *que je fasse*, etc. In none besides these are the first and second persons plural irregular.

Key to Exercise XXI.

1. Ils avaient peur de nous, mais ils auront encore plus peur de vous.
2. N'ont-ils pas honte de leur conduite ?
3. Nous aurions raison, et vous auriez tort.
4. Nous avons eu bien froid.
5. N'y avait-il pas quelqu'un dans la maison ?
6. Quel âge cet enfant a-t-il ?
7. Il aura douze ans le mois prochain.

8. Il a un peu plus de deux ans de plus que sa sœur.

9. Avez-vous bien faim? Non, merci, mais j'ai bien soif.

10. S'il n'y avait pas de feu, nous aurions bien froid.

11. Je n'ai jamais eu plus froid aux mains.

12. N'aurez-vous pas trop chaud si près du feu?

13. J'ai eu seize ans il y a quinze jours.

14. Qu'avaient ces enfants? Ils avaient peur de ce gros chien.

15. Ils auraient eu moins peur de chat que du chien.

16. Quand a eu lieu la première représentation de cette comédie?

17. Elle a eu lieu il y a un peu plus de six mois.

18. Si vous avez besoin d'un dictionnaire, prenez le mien, mais ayez en bien soin.

19. Il y a dix minutes que nous vous attendons.

20. Vous aurez beau dire; on ne vous croira pas.

Continued

GERMAN

Continued from page 2916

By P. G. Konody and Dr. Osten

LV. Comparison of Adjectives. As in English, the comparison of superiority of quality, in monosyllabic and in many dissyllabic adjectives (also in participles and adverbs), is expressed by the addition of the suffixes -r or -er in the second degree or comparative, and -st or -est in the third degree or superlative. Examples: dreist, bold; dreist-er, bolder: dreist-est, boldest. The *superlative* is either used attributively with the definite article (der, die, das dreist-este, the boldest), and with the inflections of gender and declension; or predicatively, preceded by the dative proposition am (3) with the corresponding termination of the dative. Examples: (attributive) der breit-este Tisch, the widest table: (predicative) der Tisch ist am (3) breit-esten (dative), the table is the widest [among those compared].

1. In accordance with the rule of euphony the comparative adjectives and adverbs ending in -e have only -r added to the positive; all others take -er. For the same reason adjectives ending in -el, -er, -en often cast off the -e- in the comparative: edel, noble, ed(e)l-er; finster, dark, finst(e)r-er; offen, open, off(e)n-er; verlassen, dejected, verlass(e)n-er; but the -e- is retained in besonnen, considerate, circumspect, besonnen-er.

It must be remembered that the adjectives ending in -el, -er, -en, which cast off the -e- in the comparative, retain this vowel in the superlative: eitel, vain, eitler, but eitelst; heiter, merry, heitrer, heiterst; eben, even, level, ebner, ebenst.

2. The *superlative* is formed by the addition of -est when the positive terminates in -d, -t, or in the hissing sounds -ß, -sch, -z: rund, round, rund-est; nackt, naked, nackt-est; süß, sweet, süß-est; morsch, brittle, morsch-est; stolz, proud, stolz-est; in all other cases it is formed by the addition of -st: fein, fine, delicate, fein-st; langsam, slow, langsam-st. The superlative of groß, great, größ-est (with modification of the vowel) is generally used in the shortened form größt—attributively der, die, das größte, and predicatively am größten.

In the case of many adjectives—especially monosyllabics—the comparison is not only denoted by suffixes, but also by the modification of the vowel: klug, prudent, klüg-er, klüg-st; jung, young, jüng-er, jüng-st; lang, long, läng-er, läng-st. In compounds the same adjectives do *not* modify the vowel: weltklug, worldly-wise, weltklug-er, weltklug-st; arm, poor, ärm-er, ärm-st; but blutarm, anæmic (also miserably poor, poor as a church-mouse), blutarmer, blutarmst; warm, warm, wärmer, wärmst; but brühwarm, boiling hot, brühwarmer, brühwarmst, etc.

In several adjectives both forms of comparison (with and without modified vowel) are employed alternatively: blaß, pale, blässer, blässest, or blasser, blassest; gesund, healthy, gesünder, gesündest, or gesunder, gesundest; but the comparative and superlative *without* modification of the vowel is generally preferable.

3. Irregular Comparison. The comparison of the following adjectives is irregular:

- 1, hoch, high; 2, höher; 3, höchst (the c is omitted in the comparative);
- 1, nahe, near; 2, näher; 3, nächst (a c is added in the superlative);
- 1, gut, good; 2, besser; 3, best;
- 1, viel, much; 2, mehr; 3, meist (the form „mehrst" is scarcely used);
- 1, gering (wenig), insignificant, little; 2, geringer, also minder, weniger; 3, geringst, mindest, wenigst;
- 1, früh (also ehe), early; 2, früher, eher; 3, frühest, ehest (also erst).

4. The declension of the comparative and superlative follows the mode of declension of the positive.

5. The Comparison of Equality occurs when persons or objects whose qualities are compared are of equal standing. It is formed by the particle wie, like, as (denoting equality or similarity), preceded by the demonstrative particle so or ebenso (as *or* just as), which is placed before the adjective. The adjective naturally stands in the positive: Ihre Augen waren so blau, wie der Himmel, her eyes were as blue as the sky; mein Hund ist ebenso klug, wie der seinige, my dog is just as clever as his. After ebenso the particle of superiority als, than, is also used, but wie is more correct.

6. In the Comparison of Superiority the conjunction als, than, is *always* used: er ist fleißiger als ich, he is more diligent than I. The two conjunctions used with the comparison of equality and superiority, wie and als, are very frequently confounded, even by Germans themselves.

The comparison of superiority is often intensified by the addition of such words as viel, much; sehr viel, very much; bedeu'tend, un'gemein, um ein Bedeu'tendes, considerably; etwas, something, somewhat; weit, bei weitem, far, by far; wenig, ein wenig, a little; am meisten, mostly; allerwenigstens, least, etc.

For reasons of euphony the adjectives terminating in -er, when used attributively, often form the comparative with m e h r, more, etc.—for instance, the clumsy comparative of bitter: ein bitterer-er Geschmack, a bitterer taste, is replaced as in English by: ein mehr bitterer Geschmack, a more bitter taste; or by: ein Geschmack von größerer Bitterkeit (a taste of greater bitterness). For the same reason the clumsy superlative of adjectives ending in -isch is avoided by the use of sehr, very; äußerst, un'gemein, exceedingly; höchst, most, etc. Instead of the superlative of schmeich'lerisch, adulatory, cajoling—der schmeichlerisch-este; or of phanta'stisch—der phantastisch-este, it is better to use the circumlocution: der sehr (ungemein, höchst, äußerst) schmeichlerische, phantastische.

LVI. Numerals [see XXXII.]. The *Ordinal Numerals*, substantively or adjectively used with the definite, and sometimes with the indefinite article, are derived from the *Cardinal Numerals* [page 2234], and are formed by the suffix -te added to the numerals from 1 to 19, and -ste to all others. Exceptions to this rule are the ordinal numerals of 1, eins, 3, drei, and 8, acht, which are formed: der e r s t e, der d r i t t e, der a c h t e. Thus the ordinal numerals are:

der e r s t e	der neun t e	der siebzehn t e
der zwei t e	der zehn t e	der achtzehn t e
der d r i t t e	der elf t e	der neunzehn t e
der vier t e	der zwölf t e	der zwanzig s t e
der fünf t e	der dreizehn t e	der einund-
der sechs t e	der vierzehn t e	zwanzig s t e
der sieben t e	der fünfzehn t e	etc.
der achte	der sechzehn t e	

The ordinal numbers added to the names of kings, etc., are written in Roman figures without the article, as in English, but when pronounced the article must not be omitted: Die Frauen Heinrichs VIII. (the wives of Henry VIII.) is pronounced die Frauen Heinrichs des Achten.

The declension of the ordinal numerals follows that of the attributive adjective [see XXVI.]. They can be employed as such with the indefinite article and the case ending: der zehnte, the tenth, and ein zehn t e r.

LVII. Derivatives of Numerals. From the cardinal numerals are derived:

1. The Distributive Numerals, by use of the adverb j e: je fünf, by fives; je zehn, by tens, ten of each. This form is also employed with ordinal numbers: je der erste, je der zehnte, implying the first, or the tenth, in each group. The distributive numerals are subject to declension.

2. Reiteratives are formed by the addition of the substantive -mal (times): ein-mal, zwei-mal, drei-mal, etc., once, twice, thrice, etc.; and also in connection with the indefinite numerals viel, much; manch, some; kein, none; einige, several, a few. Examples: viel-mal, many a time, often; manch-mal, sometimes, kein-mal, never; einige-male, several times: alle-mal, always; ein paar mal, a couple of times. When used as attributive adjectives, they are declined as such [see XXVI.]—*e.g.*: nach drei-malig-em Sturmlauf, after three assaults [thrice undertaken]; das einmalig-e Signal (weak, with the definite article), and einmalig- es Signal (strong, without article) genügte, one signal [the signal once given] sufficed. Mal is also applicable to ordinal numerals: zum ersten, zweiten, dritten male, etc., for the first, second, third time, etc.

3. Multiplicatives are formed by the addition of -fach, -fältig (or -faltig), -fold, indicative of multiplicity: zwei-fach, drei-fach, hundert-fach, hundert-fältig, etc., twofold, threefold, a hundred-fold, etc.; also with indefinite numerals: vielfach, vielfältig, mannigfaltig, mannigfach, many-fold. They are used as adjectives and declined.

4. Variative Numerals are formed by the addition of the suffix -erlei, which indicates variety, kind, etc.: ein-erlei, zwei-erlei, of one sort, of two sorts; and with indefinite numerals: viel-erlei, manch-erlei, mehr-erlei, all without declension and employed adverbially.

5. Distinctives are derived from the ordinal numerals by the suffix -ns or -ens (-ly): erstens, zweitens, drittens, firstly, secondly, thirdly, etc.

6. Fractional Numerals are formed by the suffix -tel, an abbreviation of the substantive Teil, part, added to the numerals from 1 to 19 (the t is dropped in 8: Acht-el; ein Drittel, one-third, is irregular) and -stel to the numerals from 19 upwards: ein Fünf-tel, one-fifth; das Acht-el, the eighth; ein Zwanzig-stel, one-twentieth. The bisection of one (1) is denoted by ein Halb (half): ein halb-es Huhn, half a chicken (used adjectively and declined): zweieinhalb Pfund, two pounds and a half. The division with halves can also be expressed by the direct amalgamation of h a l b with the ordinal numeral; two and a half can be denoted by dritt(e)halb, in the sense of three with half of the last unit missing; viert(e)halb, three and a half, etc. One and a half is expressed by anderthalb, ander (the other one) being an ancient word for "the second." H a l b, half, and ganz, whole, when used as adjectives, are declined; the other fractionals add only -s in the genitive singular, and remain unaltered in all other cases. H a l b *never* precedes the article, but must *always* follow it: eine halbe Stunde, half an hour; ein halber Tag, half a day; etc. Halb and Ganz take no article before geographical names: halb Europa, half Europe; ganz Amerika, the whole of America, etc.

LVIII. The Indefinite Numerals, wenig, a little; viel, much; all, alles, all; ein paar, a few; einige, some, several; jeder, jeglicher, jedweder, everyone; mancher, many a; keiner, none; etliche, several, are used as substantives and as attributive adjectives, and are declined as such. But wenig, little, and viel, much, remain at times undeclined when used poetically: Viel Steine gabs (gab es) und wenig Brotlaibe, literally translated: *Much* (instead of "many") stones there were and *little* (few) loaves of bread. Genug, enough; nichts, nothing; insgesamt, altogether; mehr, more; weniger, less, are not subject to declension. Beide, both, is declined like an adjective and is never *followed* by an article or pronoun: d i e

beiden Männer, both men, but never beide die Männer; meine beiden Söhne, my two sons, but not beide meine Söhne. Beide is also used substantively: Beide waren ehrliche Männer, both were honest men.

EXAMINATION PAPER

1. Which suffixes denote the comparative and the superlative in the comparison of superiority, and is there any difference in the suffixes thus employed in English and in German?
2. Which preposition must be used with the superlative of adjectives used predicatively? What is then the case of the adjective?
3. How does the consideration of euphony affect the comparison of superiority of adjectives ending in -el, -en, -er?
4. Which adjectives take the suffix -est in the superlative, and which only -st?
5. What rule concerns the formation of the superlative of adjectives ending in -el, -en, -er, which cast off the -e- in the comparative?
6. Which adjectives modify their stem-vowel in comparison, besides taking a suffix?
7. When do they *not* modify their stem-vowel?
8. Which adjectives are irregularly compared?
9. Which is the conjunction used for the comparison of equality, and by what other word is it generally preceded?
10. Which conjunction has to be employed for the comparison of superiority?
11. How do the rules of euphony affect the formation of the comparative and superlative of adjectives terminating in -er?
12. How are the ordinal numerals from 1 to 19 and from 20 upwards formed?
13. Which ordinal numerals correspond to the cardinal numerals 1, 3, 8?
14. Which additions to the cardinal numerals serve to form the distributive, reiterative, multiplicative, variative, distinctive, and fractional numerals?
15. What difference is to be noted in the use of the article with the fractional numerals halb, half, in English and in German?
16. What is the origin of the addition made to the cardinal numerals in the formation of the fractional numerals, and how is this suffix spelt in the numerals from 1 to 19 and from 20 upwards?

Exercise 1 (*a*). Form the comparative of the following adjectives:

Der Tisch ist breit. Das Seil ist dick. Der Wein The table is broad. The rope is thick. The wine ist fein. Die Rose riecht herrlich. Wir kauften is fine. The rose smells splendidly. We bought schöne Blumen. Er sah traurig aus. Der Himmel beautiful flowers. He looked sad. The sky ist düster. Der Baum ist kahl. Das Schloß war lose. is dreary. The tree is bald. The lock was loose. Mein Pferd ist edel. Mein Pferd ist von edler My horse is noble. My horse is of noble Abstammung. Er sandte mir einen flinken Boten. descent. He sent me a quick messenger. Ich sah ein schlankes Mädchen. Die Kerze brannte hell. I saw a slender girl. The candle burnt brightly.

Mein Papier ist weiß und Ihres ist gelb.
My paper is white, and yours is yellow.
Nette Leute findet man selten.
Nice people are rarely (to be) found.

(*b*) Transpose the following positives into the comparative and superlative:

Das Pferd läuft schnell. Die Sonne Italiens The horse goes [runs] swiftly. The sun of Italy scheint hell. Ich wohne nahe. Der Ton klingt shines brightly. I live near by. The note sounds rein. Das Kind lernt fleißig. Der Ballon pure. The child studies diligently. The balloon steigt hoch. rises high.

(*c*) Change the following positives into superlatives:

Dieses Kind ist eitel. Die Straße war eben. This child is vain. The road was level. Die Gesellschaft ist fröhlich und heiter. Der tiefe The company is gay and merry. The deep Brunnen war auch breit. Man muß vorsichtig sein. well was also wide. One has to be careful. Der Turm ist hoch. Das hohe Haus kostet viel. The tower is high. The high house costs much. Ich habe das gute Pferd gekauft. I have bought the good horse. Der edle Wein schmeckt gut. The fine wine tastes well.

(*d*) Fill in the missing words and suffixes.

Ich bin . . . groß . . . du. Ich bin größer . . . du. I am as tall as you. I am taller than you. Sie sind . . . . . . liebenswürdig . . . Ihre Schwester. You are just as amiable as your sister. Sie sind liebenswürdiger . . . Ihr Bruder. Dieser You are more amiable than your brother. This Schüler ist weniger fleißig . . . jener, obgleich er pupil is less diligent than that one, though he . . . . : alt ist er. Das Haar des Mädchens is just as old as he. The hair of the girl war . . . licht . . . ein Kornfeld. Das Haar des Mädchens was as fair as a cornfield. The hair of the girl war lichter . . . ein Kornfeld. was fairer than a cornfield.

Exercise 2 (*a*). Form the ordinal numbers of the following figures:

Ich war der 15 . . . in der Reihe. Der Offizier I was the fifteenth in the row. The officer las zuerst den 3 . . . Namen und dann den 8 . . . read first the third name and then the eighth. Es war am 21 . . . . Mai. It was on the 21st of May. Auf welchen Tag der Woche fällt der 1 . . April? On what day of the week falls the 1st of April? (What day of the week will April 1 be?)

(*b*) Spell the following fractional numbers: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$. $\frac{1}{7}$, $\frac{1}{8}$. $\frac{1}{15}$, $\frac{1}{20}$, $\frac{1}{30}$, $\frac{1}{40}$; and express the following in figures: anderthalb, fünft(e)halb, viert(e)halb, sechst(e)halb, dritt(e)halb.

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Exercise. Ich blies die Trompete; du empfingst ihn; die Feinde fingen den Offizier; sie gefiel mir; das Kind wuchs; die Frauen wuschen die Wäsche; wer rief mich? Du liefst schnell; er stieß mich; wann kamt ihr? Der Bursche log; er schwur einen Eid. Was taten Sie? Ich ertrug es. Wir kamen eben nach Hause; ich tat meine Pflicht.

Continued

The Quality and Colour of Furs. The Various Processes Involved in their Preparation. Making the Skins into Articles. The Feather Trade.

FURS AND FEATHERS

The covering of certain animals is known generally as fur. In speaking of a "fur," the term is applied to the pelt or skin proper, and the wool or hair attached to it. On examination of most furs, two kinds of fibres will be noticed—those making up the under-wool, which are soft and flowing, and stiffer, straighter ones, more closely resembling human hair. The latter are of service in keeping the woolly fibres from becoming matted or felted, and also assist in keeping the wool from being saturated with water, as they allow the water to shoot away as "from a duck's back."

The value of a fur-skin depends upon the colour, texture, and durability of these fibres, and also upon the nature of the pelt; and it is because they possess one or all of these characters to a high degree that certain skins are held in such high estimation.

Colour and Quality. The colour of wild animals is generally well adapted to the surroundings amongst which they severally live and have their being. Generally speaking, the farther north we go, the lighter do we find the prevailing colours, but it is only in the extreme north that white animals are found in any appreciable quantity. Cold has a marked influence on colour, and many animals whose summer coat is grey or even drab assume during the winter a more or less pure white colouring, though, as a rule, certain portions retain their original share of pigment, as, for example, the Arctic hare, which has some pigment remaining in the tips of the ears, and the ermine, in which the tail is yellowish-white at the root and black at the tip.

Like colour, quality is influenced by climatic conditions. As a rule, the colder the winter, the better is the fur, and the skins taken about mid-winter are usually the best both in quality and colour. When the new coat begins to appear, certain of the half-grown fibres are to be seen. A skin in this condition is said to be "stagey," and is generally much poorer in quality. Summer skins are those obtained from animals wearing their summer clothing. These also are of considerably lower quality than those taken in winter.

The Application of Furs. In the first place it should be pointed out that the skins of fur-bearing animals are used for two main purposes. Their chief application is to the manufacture of articles for domestic use—wearing apparel, rugs, etc. In the second place, the fur, after being separated from the pelt, is converted by pressure into felt used in the making of hats, cloth, and so on. In addition to these uses, there are certain other industries on a smaller scale which deal in fur products, as, for example, the manufacture of badger-hair brushes, and of artists' brushes from sable and kolinski tails. Our chief concern will be with the fur trade proper in connection with the collecting, trading, preparing of furs, and their manufacture into saleable articles of clothing.

Before proceeding to an account of the treatment of furs, it will be as well to give a short account of the fur-bearing animals. For details concerning their nature, habits, and relationships, see the course on NATURAL HISTORY. We shall consider them here only so far as they are important from the furrier's point of view.

FUR-BEARING ANIMALS

Badger. Rather stiff greyish upper hair, and whitish under-wool. The hair is used for making brushes.

Bear. Various species are used by the furrier. Fur varies much in colour and quality, that of the cubs being woolly, while that of more adult members is stiffer.

The *Grizzly Bear* has under-wool brown or dark brown, and the hair almost black. Certain skins yield hair suitable for brushmaking, but the majority is used for ordinary furrier's work, and large numbers are employed in the manufacture of caps and robes for military purposes.

In the *Polar Bear* the fur of the young is quite white, but becomes yellower with age, though some adult specimens are of an almost pure white. A certain number of skins are used for rugs.

Beaver. Two species only are known—the European and the American. The fur is a very beautiful one of a grey-brown or reddish colour, with rather long, somewhat stiff hairs. Usually, beaver skins are "pulled"—that is to say, the upper hair is removed and the colour of the fur altered by a chemical process known as "silvering." Beaver is used largely for trimmings, coat linings, and sundry other purposes, the old application to the making of hats being practically a dead industry. The numbers annually taken have of recent years shown a marked decrease, owing to persistent hunting.

Buffalo. Hair rather coarse and dun in colour. Used chiefly for making leather, though the finest skins are made into robes.

Cat. Various species used in fur work. The domestic cat, of which large numbers are obtained from the Continent (more particularly from Holland), is used in large quantity for fur work of an inferior kind. The skins are made into linings for coats and similar articles of clothing, and these are known as "genet." Fur poor in quality; colours various.

Wild Cat. Poor in quality and in limited demand.

Civet Cat. Sometimes used on account of singular markings.

Chinchilla. The hair is very soft and of almost the same length as the fur. The fur is long and silky, in the ground parts of a dark slate colour, while the upper portions are silvery grey. Used very largely for muffs, boas, and trimmings.

Another variety, known as *Bastard Chinchilla*, comes from Chili. The skins are smaller and the fur poorer than the real chinchilla.

Caragan. A variety of fox found on the steppes.

Deer. The hair is rather short and stiff. Chiefly used for making mats, rugs, etc.

Ermine. Hair and fur both soft. The best almost pure white. Inferior qualities have a more yellowish tinge, and are frequently bleached before use. Tail yellowish, with a black tip. Used for muffs, boas, trimmings, etc.

Fisher. Fur rich and close, hair long, dark and glossy. Pelt strong, and the whole skin of a durable nature.

Fitch, or polecat. Hair long, with dark tips. Fur light grey to yellow. Used very largely for cheaper varieties of fur work.

Fox. Many species and varieties, used for all kinds of fur work.

Black Fox. Best from Labrador. Fur fine, and dark in colour. Hair long and glossy. Value varies according to colour, the darkest being the most valuable.

Blue Fox. Best from Archangel. Fur soft and woolly, of a blue colour; hair of a grey-blue colour.

Cross Fox. Fur pale in colour; hair darker at the tips, the darkest parts being along the spine and across the shoulders, making a distinct cross.

Grey Fox. Fur greyish or yellowish; hair silver-grey on the back, more yellow on the sides.

Japan Fox. Poorer in quality than above. Hair greyish and somewhat stiff and short.

Kitt Fox. Skins small; fur and hair rather soft.

Red Fox. Colour of fur various, yellowish to blue-grey. Hair yellow to a rich dark red.

Silver Fox. A variety of the black fox. Fur dark in colour, hair silvery white.

White Fox. Fur and hair pure white, though the former often has a tinge of blue. Sometimes darker hairs are present. These lower the value of the skin. Enormous numbers are dyed various shades.

Goat. Found in many parts of the world. The Angora possesses fine silky fur, and is largely employed in the making of rugs. Certain kinds of goat obtained from Thibet and China come into the London market in enormous quantities, and are classified according to colour into "whites," "greys," and "natural blacks." The best skins of the last-named class are dyed to imitate bear, and are much used in the manufacture of rugs.

Guanaco. Colour reddish to yellow. Chiefly employed for making carriage rugs, etc.

Hamster. Fur and hair short, yellow to grey, with curiously shaped black markings down the back. Made into linings for coats, cloaks, etc.

Hare. Fur soft and fine, hair long and fine, pelt weak. Pure white found in Russia and Siberia in enormous numbers. Thousands used in this country in the natural state, and dyed to imitate the more costly varieties of furs. Sold by the *poud* (a Russian measure). Value according to the weight in *pouds* of 100 skins.

Kaluga. Practically no fur, but very short hair. Poor skins in every way, both as regards fur and pelt. Colour grey, yellow, or reddish. Made into coat linings, etc., and often dyed some darker colour.

Kangaroo. Various species used to a slight extent.

Kolinski. Fur soft and short, of a blue-grey colour in the ground, lighter on the top; hair yellow to orange-red: skins generally dyed to look like sable, and used for muffs, stoles, etc. The hairs from kolinski tails are used in making artists' brushes and pencils.

Lamb. Many varieties are known in the fur trade, and have received names according to the districts from which they are obtained—*e.g.*, Persian, Ukraine, Astrachan, etc. The fur is curly, the value depending on the size and tightness of the curl. The better the curl, the more valuable the skin.

Persian lamb is the most valuable, as, when dyed, it takes a most beautiful gloss. Ukraine, Astrachan, etc., are less valuable, but are largely used. Colours are various. A certain number of pure white skins are used in the natural state, but most are dyed black and used for muffs, ties, ladies' jackets, coat collars, and linings, etc. "Slink lamb" is the generic term for certain species born prematurely. Lamb from Western Europe has a longer wool, and is used for lining gloves, etc.

Leopard. Used for rugs, etc.

Lion. Used for rugs, etc.

Lynx. Fur grey, yellowish or bluish. Hair fine and soft, of a greyish colour, flecked with black. Many used in a natural state for ties, etc., some dyed, chiefly blue and black colours.

Marmot. Fur is rather harsh, generally of a greyish-black colour in the ground, becoming lighter and more yellowish-red at the top. The hair is reddish, often speckled with black, and rather stiff and harsh. The skins are generally dyed to imitate the more costly sable.

Marten. The whole genus is characterised by a certain softness and richness of the fur, which makes them amongst the most highly esteemed furs.

American Marten. The fur is bluish-grey, except under the throat, where it is a yellowish-white. The top of the fur is lighter in colour, and the hair varies from a light yellow to a rich dark brown. Next to the Russian sable, it is the most valuable skin of the marten tribe. The darker the skin, the more valuable it becomes.

Baum Marten. Fur rather like that of American marten, but somewhat lighter. The hair is fine and soft, and varies in colour from light yellow to dark brown. The fur on the throat is of a yellow to deep orange colour.

Japanese Marten. This is a much less valuable fur than the preceding, both on account of its harsher nature and of its brilliant colouring value, which ranges from yellow to orange.

Japanese Sable. In character this skin rather resembles that of the Chinese sable, which seems to be a variety of the Russian sable.

Russian Sable. One of the most highly prized furs. The fur of the best skins is of a rich, greyish-blue in the ground, becoming somewhat lighter towards the top. In character it is exceedingly soft and "full." The hair is dark brown and glossy, and here and there greyish hairs are to be seen. The lighter-coloured skins are much less valuable, and are frequently dyed to look more like the darker natural skins.

Stone Marten. The fur is of a lighter colour than that of the other martens, and is generally of a pale greyish-blue colour, though in many skins it is almost white. The hair is very long and less soft than in the other species. In the best skins it is of a dark brown colour.

Mink. Various species are used.

American Mink. The fur and hair are short, and vary from a pale yellow to a rich brown. The upper lip is generally white, and there are also patches on the breast.

Japanese Mink. Closely allied to the Siberian mink, and resembles the polecat tribe. Its fur is short, rather harsh, and of a yellowish colour.

Mole. Very fine, soft fur, short and close, of a bluish-grey colour. Has been used in exceedingly large numbers during recent years for jackets, etc.

Mongolian. Under this name are included the skins of various animals from Thibet and China. The skins of certain kids from these districts are sewn together in the form of a Maltese cross, and are known as China kid crosses. The small pieces of fur which cover the legs are also made up in a similar fashion, and are sold under the name of "kid-leg crosses." They are generally classified according to colours, four principal varieties being recognised—viz., grey, white, black, and mixed, or spotted. The value depends on the quality and length of the fur, the longer and coarser varieties being the least valuable. The name "Mongolian" is often used as synonymous with Thibet lamb, a species of sheep having long, soft, curly wool.

Monkey. Certain species from West Africa, with fur of a bluish-grey colour, have a limited use.

Moufflon. The hair is "pulled," leaving a soft wool. Skins are dyed various colours—blue, grey, etc.—and are used for making necklets, etc. The true moufflon (*Ovis musimon*) is found only in Corsica and Sardinia. The skins of certain Mongolian goats are also known as moufflon.

Musquash. The hair is coarse and generally dark, the fur soft, close, and of a rich grey-blue to slate colour. When "pulled," the fur shorn so as to be of about 14 millimetres in length, and dyed, these skins are used very largely for making ladies' jackets, as the finished article is a very passable imitation of sealskin. One variety, known as "natural black musquash," obtained from Maryland and Delaware, is of much greater value than the ordinary kind.

Nutria. The hair is coarse and stiff, and is usually removed by "pulling." The fur is short and close, and of a rich brown colour. For use as trimmings for ladies' garments it is often "silvered." The fur of skins of which the pelt is damaged is much used for felt manufacture.

Opossum. Two varieties are used by the furrier—the American and the Australian. The characters of the furs of these two animals are quite different. In the American opossum the hair is long and coarse, often split at the ends. The fur is generally white or ashy grey. In the Australian opossum the hair is shorter, less stiff, and the whole effect is more woolly than in the American form. The colour is usually blue-grey on the back, while the belly fur is white or yellowish.

Platypus. Found in Australia and Tasmania. The fur is not of first-rate quality, and has a very limited use.

Rabbit fur is one of the most largely used. Many thousands of tame rabbit skins are used on the Continent. When shorn and dyed, they are used as an imitation of sealskin under the name of "electric seal." Several varieties are known to furriers and fur merchants, and amongst them may be mentioned Blue Rabbit. The last-named is used as imitation ermine, and for millinery purposes. The fur is also largely employed in the manufacture of felt for hats, etc.

Raccoon. Fur long and well developed, greyish or yellowish-grey in colour; hair often flecked. Pelt strong and durable. Largely used for linings and rugs. The tail is ringed with black.

Sea Otter. One of the most valuable furs at present in use. Formerly it was comparatively common, but persistent hunting has greatly reduced the numbers. The fur is very full, rich, and soft, and its colour varies from a greyish-brown to an exceedingly dark brown. The pelt is extraordinarily strong and thick.

Seal. Under this name are included many species which may be conveniently divided into two main groups—the fur seals and the hair seals. In the former class the fur is very thick and soft, while in the latter it is reduced to a minimum.

The Fur Seals. There are four species used in the fur trade which are classified according to the districts from which they are taken.

Alaska Fur Seal. The hair is stiff and strong, the colour varying according to age. The fur or wool is very thick, and after removal of the hair is seen to be of a greyish-yellow or brown colour, and tightly curled.

Cape Horn Seal. Found in the South Pacific. "Lobos" skins, caught near the Lobos Islands, belong to this species. The fur, as a rule, is not so thick as in the Alaska seal.

Cape of Good Hope Seal. Somewhat similar in general characters to the Cape Horn seal.

New Zealand Seal. The fur in favourable specimens of "South Sea" skins is very long and full.

The quality of the fur depends to a great extent upon the age of the animal. Three or four year old seals generally possess the richest and thickest fur. According to the size they are sorted and named as follows, beginning with the largest: Wigs, middlings, middlings and smalls, large pups, middling pups, small pups, extra small pups, grey pups, and black pups. Further details concerning fur seals is given later.

The Hair Seals. Various species from the Pacific are known to commerce—*e.g.*, the Cape sea lion, the Northern sea lion, the Californian hair seal, and the Australian seal. Those most frequently met with are the Atlantic varieties, of which the following are the most commonly used.

Grey Seal. Certain numbers breed in the Shetland Islands. Not very plentiful.

Common Seal. The hair is yellowish with black spots on the back and flanks, yellowish-white on the belly.

Ringed Seal. The hair is stiff and of a yellowish colour, marked down the back and flanks in the form of rings of blue or black hair.

Blue-back. The hair of the back is a bluish-grey—sometimes quite a dark blue—while on the flanks and belly it is white or yellowish-white.

Whitecoat. The young of various species of hair seals having their first coat are known as whitecoats. The fur is soft, the hair softer than in the adult, and varying in colour from silvery white to light yellow. Some are even of a pale orange colour. The hair seals are used chiefly for the making of coats for motoring, though whitecoats, when dyed, are used for making military caps, etc.

Sheep. Three kinds of wild sheep are used in the fur trade—viz., the argali, from Siberia; the moufflon, from Sardinia; and the American sheep. There is generally a stiff hair and a soft under-wool. The former is usually removed by the process known as "pulling."

Skunk. Of a dark brown, almost black colour, with dark under-wool. Generally, there is a more or less well-defined white stripe of a V-shape. Dark skunk are valuable skins, both on account of their colour and durability. The white stripes are often cut out, sewn together, and then dyed to imitate the darker portions. Largely used for muffs, ties, collars, etc.

Squirrel. The common red squirrel is not much employed, the kind chiefly valued being the Russian and Siberian. The fur is soft, full, and of a rich dark slate colour, and the hair is grey, slightly flecked with a darker blue. The belly is white, while the flanks are often slightly red. Squirrel is largely used for coat linings. The skins are divided into back and belly, and the backs made into what are known as sacs. These, when dyed of a sable colour, form a very tolerable sable imitation. The bellies are also sewn together to make "squirrel lock sacs."

Tiger. Found in Asia Chiefly used for making rugs.

Vicuna. Has practically the same distribution and characteristics—as regards fur—as the guanaco, and the skins are employed for similar purposes.

Wallaby. Fur soft; hair rather long, and of a greyish colour. Largely used, when dyed, as an imitation of the hair of the skunk.

Wolf. Hair fine, wool soft, and very liable to "felt." Colour varies from yellowish-grey to blue, some skins having hair that is almost black.

Wolverine. Fur soft and thick. Colour somewhat similar to that of the wolf.

The Trade in Furs. At the present day there are certain recognised centres of the fur trade, and to these almost all the skins are brought and sold, either by private treaty or by public auction. Amongst these centres are London, Leipzig, Nijni-Novgorod, and Irbit. To the London market come all the goods belonging to the Hudson's Bay Company. These are sold by public auction twice a year, in January and March, the chief skins being beaver, musquash, red fox, white fox, cross fox, kitt fox, silver fox, mink, otter, American marten (known as Hudson's Bay sable), fisher, lynx, wolverine, and wolf.

Furs collected in America other than those of the Hudson's Bay Company are sent direct to London—and a small number to Leipzig—where they are received by commission agents and subsequently sold. To London also come most of the South American (chinchilla, guanaco, nutria, etc.) and Australian furs (opossum, wallaby, kangaroo, etc.), as well as large numbers of what are known as "China goods," including goats, Thibet lambs, China kid, and kid crosses, Jap fox, Chinese sable, weasel, kolinski.

The fur sales in London take place in January, March, June, October, and December. At the December sales practically the whole of the world's seal catch is disposed of to merchants, who distribute them between London and Paris for dressing, dyeing, and those subsequent operations which are necessary before they are ready to be made into jackets and other articles. At the March sales, which are the largest, almost every conceivable variety of skin is to be seen, and at this time of year certain parts of the City seem to be more than usually cosmopolitan, for merchants come from the ends of the earth to prepare for the following winter. The China goods are sold mostly in January, and, as in every other branch of trade today, there is a tendency to specialisation to be seen, for certain business houses devote almost the whole of their attention to this China trade. About Easter time Leipzig presents a similar cosmopolitan aspect, for then the great fur fair is held. At this fair the majority of the goods sold are those obtained from the Continent of Europe, including part of the Russian produce; and, in addition to the various kinds of sable and marten, such as stone and baum marten, fitch, kolinski, etc., large numbers of American skins—skunk, beaver, musquash, and the like—are sold.

To Irbit, one of the centres of the Russian trade in furs, are brought Russian furs, such as marmot, hare and fitch, white fox, ermine and squirrel, as well as lambs of many kinds—Persian, Ukraine, Krimmer, Astrachan, and others. The skins are sorted, half-prepared, and sold, to come eventually to Western Europe, often *via* Leipzig and London.

The fair at Nijni-Novgorod was formerly the greatest in the world. Here East and West met to haggle and barter, buy and sell. Today, however, it is of considerably less importance, though still the centre for Siberian goods, such as ermine, hare, sable, squirrel, and other furs.

At the London sales all goods are sold by public auction to the highest bidder. Goods must be cleared from the warehouses by a certain fixed date, so that many merchants and furriers who do not wish to have their goods worked immediately have them warehoused. Some skins are best kept in cold stores; for others it is sufficient to put them away at the ordinary temperature with some substance which will prevent them from being attacked by moth. Camphor is excellent for this purpose, but on account of its lower price naphthalene is much more largely used.

Tariffs and Duty on Furs. The Customs duty on furs was abolished in 1845, after having been reduced three years earlier, so that all skins, whether raw, dressed, or dyed, come into this country free of charge. The same applies to Germany, but in France dressed and dyed skins are charged duty according to tariff, with the exception of certain China goods and some kinds of hair seals.

All raw goods are admitted duty free into the United States, but charges are made upon dressed skins amounting to about 20 per cent. of the value, while for manufactured articles an even higher rate is charged.

There are also certain tariff charges in Canada and some of the Australian Colonies.

So much, then, for the trade in raw products on the large scale. The courses usually adopted in retailing are two in number. The merchant, having obtained his goods, sorts them according to colour and quality, and either sells them in the raw state to the furrier, or to another merchant, or hands them over to the fur-skin dresser and dyer. By the latter they are dressed—that is to say, the hard, horny skin is converted into a soft, pliable pelt of the nature of chamois leather, and, if necessary, shaved down to a suitable thickness. Certain goods require dyeing in order to improve their lustre and colour generally, or so to change them in

appearance that they resemble a more costly and pleasing fur. From the dresser and dyer they pass once more into the hands of the merchant; from him to the furrier, and so to the retailer of the finished articles. Certain furriers, however, prefer to buy the raw goods from the merchant, and have them prepared according as they are needed—this applying particularly to the more valuable varieties.

Prices of Skins. There are various causes which determine the prices, the principal being demand, which is ruled by the dictates of fashion, and supply, which is practically beyond control. Some seasons ago there was a large demand for moleskins, and whilst the fashion lasted millions of skins were made up into jackets, muffs, and other articles of wearing apparel. Then the demand lessened, and, in consequence, far fewer skins came to the market. Persistent hunting frequently causes a shortage in numbers, and disease and increase in the number of the natural enemies of fur-bearing animals are also contributing factors.

A polar bear skin may vary in price from £1 to £25, and a silver fox skin from £2 to £220. Sea otter varies as widely. Badger varies from a shilling to a sovereign in value, beaver from ten shillings to fifty shillings, chinchilla from four shillings to £7 or £8. Blue fox may fetch up to £10. Among high prices for the finest skins are otter £10, raccoon £16, Russian sable £25, American marten £15, lynx two guineas, wolf fifty shillings, and the same for the wolverine. A very good skin of the common cat is worth half-a-crown, and of the wild cat three times as much. The squirrel sells for from sixpence to eighteenpence.

There are few who would recognise as things of value the rather unpleasant skin of the fur seal as it comes to the fur-dresser, covered with salt on the fur side and its natural coat of thick blubber on the pelt side, or the shapeless-looking object with a hard, horny skin which later forms part of my lady's sable set. Yet it is to this recognition of value and quality in the raw state that most capable fur merchants owe their success, and it is due to the skill and energy of the dresser that the pelt is made into leather as soft as chamois, and the fur and hair cleaned and laid as Nature intended, so that the unsightly and often evil-smelling raw skin becomes a thing of beauty and a joy to its owner. Frequently furs which are inferior in natural colour are dyed to resemble the more pleasing skins, and of this process more is said later.

1. THE FURRIER'S TOOLS

a. Beaming knife *b.* Furrier's knife *c.* Shaver's steel *d.* Slecker *e.* Unhairer's pulling knife. *f.* Blubbering knife *g.* Moon knife *h.* Cross-handled shaver's knife

Curing the Skins. The first process—the curing of the skins—is usually performed by those engaged in the work of capturing fur-bearing animals. It consists essentially in removing the skin with its attached fur from the body, removing excess of fat, and drying in the air. Certain skins, however, such as fur seals, bluebacks, calves, etc., are dressed with salt before packing. Mention is made of this later when considering the dressing of seals.

As stated, in the case of most animals the skin is stripped from the body and dried. This removal of the skin is usually effected in one of the three following ways: (1) An incision is made in the middle line of the ventral surface from mouth to rump, and the skin carefully cut away. This method is most universally employed in the case of marmot, chinchilla, and Australian furs, such as wallaby and opossum. Large skins—*e.g.*, bear, goat, sheep, etc.—are also treated in this manner. (2) The animal is opened at the mouth and rump and the body of the animal drawn through. This is by far the most usual practice, and most of the smaller skins with which the fur-dresser has to deal are thus obtained. (3) The body is drawn through the mouth, leaving the rump or "breech" end closed. Usually the legs and tail are opened and the bones removed, though so cleverly is this method employed by certain hunters that although the breech is not opened the tail and leg bones are taken out, in all probability with some sharp, rod-like instrument. Many Russian sable and stone marten come to the dresser in this fashion.

2. THE FLESHER AT WORK

One animal—the nutria, from the River Plate—is remarkable in that the belly fur is better than that of the back, and in consequence the removal of the skin is always effected by making a longitudinal incision down the centre of the back instead of the belly. As a rule, the head, legs, and tail are left attached, though this is by no means a universal custom. In seals, the fore flippers are cut off, and in the skin as received from the curing-house are to be seen two round or elliptical holes marking the places which the flippers occupied. Many skins, such as goat, Thibet, marmot, wallaby, and nutria, find their way in the first instance into the English wholesale market minus heads and tails and legs.

The Drying Process. Where the method of salting is not employed, the next process is that of drying. Where the skins are "cased" or "round"—*i.e.*, obtained by method 2 and 3 above—they are dried with the fur inside. If "open"—method 1, above—the skins are merely spread open, pelt uppermost. It is during this drying that a certain number of skins become "burnt," owing to great heat, or sometimes on account of "taint" present in the skin. When a skin is "burnt," the pelt is converted into a very hard, horny substance which resists all subsequent attempts to convert it into leather. Some skins seem much more liable to this burning than others; for example, one frequently finds burnt patches in bear, wallaby, and marmot; more rarely in fox, sable, squirrel, and such-like small skins. Seals are cured with salt, laid in piles, and after remaining in the salt for about fourteen to twenty-one days, are corded up in rolls and shipped. Ordinary dried skins are packed in bales, fur to fur if "open," pelt outwards if "cased," though naturally the exact modes of packing differ according to the kind of skins and the customs of the district from which they come.

The first operation necessary for the conversion of the skin into leather is the one known as *fleshing*. The skins are first treated with water—sometimes with a weak brine—allowed to remain a certain length of time in order to become soft, and then the surplus fat and connective tissue removed by pulling them over a knife of the type shown in 2.

Grease Dressing. The skins are then eady for the next operation, which is that of *greasing*. For this purpose, grease of special nature (English dressers generally use animal oils, while in France colza and other vegetable oils are employed) is smeared over the pelt, allowed to soak in, and then the skins are subjected to a process by which the fats are driven into the substance of the pelt, rendering it soft and pliable. This is accomplished in one of two ways, according to the nature of the pelt. For small skins and such as possess a tender pelt the process of *foot tubbing* is employed. The skins, thoroughly greased, are placed in tubs inclined at a slight angle to the vertical, in which men with bare feet stand. By a continuous up and down motion of the feet the skins are constantly turned over and over, the grease is worked into the substance of the skin, and the result is a soft, supple pelt. During this process, a certain amount of heat is developed by the constant friction, and this in no small measure helps towards the accomplishment of the object in question.

3. DRUM FOR CLEANING SKINS

4. SHEEP SKIN DRYING IN FRAME

5. SEAL SKIN DRYING IN HOOP

In the case of skins having a stronger and heavier pelt a different method is employed. After greasing, they are placed in a mill which consists essentially of a box into which a wooden block descends. This block is attached to the end of a lever, and the whole is so constructed that the skins receive a hard blow at the moment of the fall of the lever, and at the same time are pushed slightly away from their former position. Here, again, a turning is effected, and the amount of heat developed is quite considerable. This method is the one always followed for heavy skins, such as seals, bluebacks, wallaby, etc., and is, of course, more economical than the slower process of tubbing. As might be expected, the length of time taken in each of these operations varies enormously. In some cases the skins are greased again, and the leathering process repeated. No definite rules can be given; the judgment of the dresser alone can decide when the skins are sufficiently leathered.

Removal of Excess of Grease. The skins at this stage are very greasy, and require careful cleaning before they appear in any way presentable. The chief substance used as an absorbent for this excess of grease is sawdust, though other materials are used, such as plaster of Paris and French chalk. Some French dressers sometimes mix a small amount of fine sand with their dust in order to secure more perfect cleaning. The greasy skins are worked about in the dust either in the foot-tub or in a mill like the one described above, except that it is boxed in, and so has received the name of a *box-mill*. Finally, the skins are turned fur outwards, if cased, and the fur cleaned in a similar fashion in what is known as a *drum* [3]. A drum consists of a hollow cylinder of iron or wood mounted on an axle and capable of rotation about this as an axis. Into the drum are placed the skins and sawdust, or whatever the cleaning material used may be, and the drum caused to revolve for a varying length of time. To free them from dust, the operation of *caging* is necessary. The process is a simple one. They are placed in a wire cage, mounted like the drum just mentioned, and as the cage revolves the particles of dust are beaten out, and fall through the meshes of the cage.

Finally, the skins are *shaped*—that is, stretched so as to look somewhat natural in appearance, and, if necessary, the pelt *knifed*—that is, pulled over a knife similar to the one used by the flesher [2], in order to further soften it and to remove inequalities; beaten with canes in order to free the wool from felt and to make it free and

lowing, and any parts of the pelt which may be torn carefully repaired.

This, in short outline, is the process of grease dressing, but there are so many details to be carefully observed, and so many pitfalls for the unwary, that it is only after much experience that really good work can be obtained.

Other Methods of Dressing Furs. Many other methods of dressing are in vogue. For example, the white Russian and Siberian hares come to this country in the dressed state; the leather, which is not by any means good, is made by soaking the skins in a solution of alum to which barleymeal is added. On drying, the pelt is left white, and is covered with very fine dust—a mixture of alum and meal.

China goods, such as goats, Thibet lamb, and kid-crosses are native-dressed with Glauber's salt and rice flour. This, like the Russian method, does not give a leather which is at all to be compared with that obtained by grease dressing.

Much of the German dressing is done by a quick process involving the use of sulphuric acid. For certain skins this method seems peculiarly well adapted, though for others the results are inferior to those obtained by the grease method.

The dressing of long-haired sheepskins is usually done with alum and salt. The skins are first scoured with soap and soda to remove grease, the pelt is scraped with various kinds of knives—*e.g.*, beaming knife [1*a*], and then a solution of alum and common salt is rubbed into the pelt, this last-named operation being repeated several times. The skin is then stretched out in a *frame* as shown in 4 and allowed to dry slowly.

Fur Seal Dressing. In the case of fur seals of all kinds the procedure is somewhat different, and is as follows: First of all, the thick coating of fat is removed by what is known as *blubbering*. The skin is laid, pelt uppermost, on a *beam* similar to the one used by the unhairer [6], and the fat scraped off with a special kind of knife—a blubbering knife [1*f*]. After this the skins are washed in a warm solution of soap and soda to get rid of grease from the fur, and they then undergo the process of *hooping*. This consists in stretching out the skin in an oval iron hoop by means of string passed alternately through the edge of the skin and round the hoop. Figure 5 shows a seal in the hoop. Next follows the process of *unhairing*. As previously explained, the fur seal possesses a beautiful soft under-wool and stiff upper hairs. By wetting the fur and then drying quickly these latter are so much loosened as to be easily removed by means of an unhairer's knife. The skin is placed over a beam, and the hair removed by a pushing motion of the knife. An unhairer is seen at work in 6. Even after this some hairs are left, and to get rid of these a pulling knife [1*e*] is used. The hair is caught between the blade and thumb and pulled out. This process of pulling is usually employed in dealing with otter, beaver, and nutria.

6. UNHAIRER AT WORK

7. SHAVERS AT WORK

There are probably no trade secrets so jealously guarded as those of the fur dyer. The particulars of the composition of various colours and dye-baths are known only to a very limited number, and these particulars are handed down from generation to generation with such modifications as are of necessity introduced.

The principal centres of this industry are London, Leipzig, and Paris, though the work is also carried on to some extent in various towns in France — *e.g.*, Lyons—in Belgium, and in America.

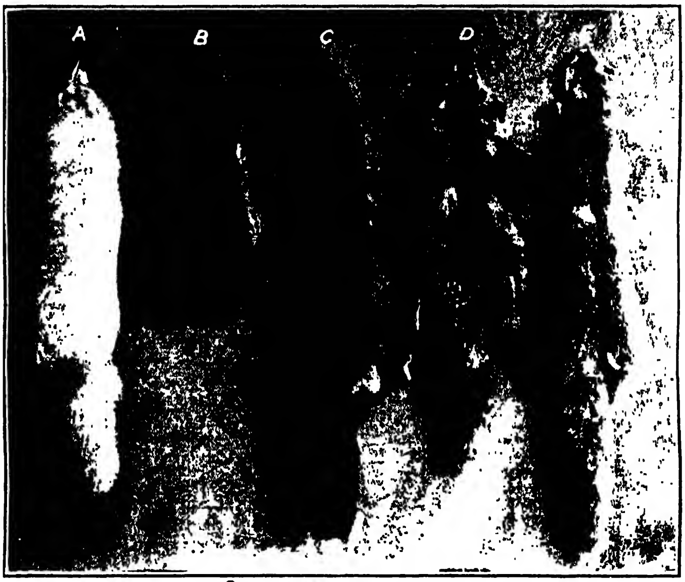
Materials Employed for Dyeing Furs. When it is remembered that the majority of the furs used in every-day life are of very sober appearance — black, sable, brown, etc.—it is easy to see that the wide range of colours obtainable by the use of dyestuffs derived from coal-tar products is useless to the fur dyer. He may require blues and reds and yellows for shading purposes, but to all intents and purposes, it will be seen that the so-called aniline dye industry derives but little support from him.

Nor is the limited choice of colours the only explanation of this fact. Most artificially prepared dyestuffs are only taken up from solution by the animal fibre at a temperature approaching the boiling point of water. Such substances are useless for dyeing furs, because, not only would the fibres themselves be injured at such a temperature, but the pelt would lose its supple nature and become hard and horny, and so worthless from the furrier's point of view; and, further, the hair and wool would become loosened, and readily detachable from the leather. In consequence, the dyer of furs must choose such substances as will be absorbed by the fibre at a low temperature—that is to say, not higher than about 50° C. Amongst such dyestuffs, those of natural origin occupy the first place, and they are therefore largely used. Blacks are obtained by means of

logwood and various metallic mordants, such as chromium, iron and copper; blues with various materials containing tannin substances, such as galls and sumach; yellows and browns with cutch, gambier, and turmeric. In addition to these other dyes are used for special purposes and for obtaining shades of colours.

Preparations for Dyeing. The covering described generally as fur consists, as previously stated, of two parts—the wool lying at the bottom next the pelt, and the stiffer upper hair. The outer covering of a hair is composed of a substance known as keratin, which is of a similar nature to the materials which go to make up the outer layers of the skin, nails, and hoofs. This possesses to a high degree the property of resisting the action of dyestuffs, and as it forms a layer which is very impenetrable, the colouring matter reaches the medulla of the hair only with difficulty. Consequently, before the hairs can be made to take up colour, this layer must be softened, so as to become more absorbent and to allow of the passage of the dyestuff into the medulla.

This object is achieved by a process known as *killing*. The killing is applied to the tips—in some cases to the wool as well—by means of a feather or a brush, and is usually of an alkaline nature, such as lime, soda, etc. As a result of this application the fibres are softened, and so more readily take up dyestuffs. Then follows a process known as *mordanting*. The skins are either brushed with or dipped in a solution of the mordant, the composition of which varies with the shade of colour required and the dyestuff subsequently used. Logwood, for example, is a polygenetic dyestuff—that is, with different mordants, different colours are obtained. Thus, with alum mordants, greyish violet shades are obtained; with chromium, iron and copper mordants, grey to black is the resulting colour; while tin mordants yield reddish violets. The principle underlying this process of mordanting is this: Certain metallic salts are absorbed by the fibre, and as a result of decomposition in and on the fibre—*e.g.*, aluminium acetate—or of oxidation—*e.g.*, ferrous salts, a *mordant*, usually a hydrated oxide or a basic salt, is formed. This mordant possesses the property of combining with dyestuffs to form *colour lakes*, to the presence of which in the fibre the final colour is due. It is usual to allow goods that have been mordanted to remain exposed to the air for some time before they are put into the dye, to allow the above-mentioned decomposition to take place.



8. SPECIMENS OF FOX

White fox *b.* Jap fox :. Kamchatka red fox *d.* Cross fox *e.* American red fox

The Dyeing Process. After mordanting the goods are ready for the dye. This is either applied with a brush, or the skins are immersed in the dye-vat and allowed to remain for such time as previous experience has shown to be necessary. In some cases the skins may be dipped twice or even four times, a definite period being allowed between each dip, during which time the skins are allowed to air. By this means oxidation takes place and the colour becomes fixed.

In using some materials—*e.g.* logwood—a different method is occasionally adopted. Instead of mordanting and dyeing in separate baths, one bath is made containing the mordant and dyestuff together. This, however, is not a common practice, as there is a considerable loss of colouring matter on account of combination between mordant and dyestuff, whereby the insoluble lake is precipitated, and has no opportunity of being fixed upon the fibre.

Of recent years a new class of dyestuff suitable for fur dyeing has been placed upon the market. These substances are chemical compounds prepared from coal-tar products, which on oxidation yield insoluble matters varying in colour from light brown to black. Some of them are exceedingly useful to the dyer, though for some purposes they are much inferior to the natural products.

How to Apply the Dye. In the dyeing of certain classes of skins it is advisable to apply the colour with a brush rather than by dipping them into dye bath. This is well illustrated in the case of the fur seal. On examination of the fur of a sealskin jacket, it will be seen that the colour of the lower part of the fur, or the *ground*, as it is called, is of a deep brown colour, while the top is much darker—almost black, in fact. This result is attained by brushing the fur with mordants and colours to different depths. That is to say, several brushings are made to a fixed level—care being taken that the same level is reached at each operation—with one mixture, and later another mixture is applied to the ground. The latter application produces a different colour where the fur has been previously treated, and so a distinction between *top* and *ground* is produced.

In the case of sable, marten, fitch, and such like skins, a large number is found in which the upper hairs or *tips* are too light to be quite pleasing. To correct this defect, and to accentuate the natural dark stripe which runs down the centre of the back, colour is carefully applied by means of a feather or a

light pad, this process being known as *tipping and striping*

Beaver and nutria are skins which, after *pulling*, or removal of the top hair, are frequently *silvered*. This operation of silvering consists in the light application of various substances, which produce a lustrous appearance and considerably enhance the beauty of the skins.

Imitation Furs. Apart from the improvement in colour of natural skins, there is another branch of the fur-dyeing industry which is of great importance. This is the dyeing of cheap kinds so that they resemble to a certain extent the more costly furs. Enormous numbers of white Russian hares are dyed to imitate sable, Russian sable, stone marten, etc.; marmot are dyed sable colour; white fox and red fox are made to look like blue fox and silver fox respectively. Of course, it is only in the colour that there is any resemblance between the real and the imitation fur. One can no more make a Russian sable out of a white hare than the proverbial silk purse from a sow's ear, but to the uninitiated there is no very obvious difference in appearance between a jacket made of electric seal, which is only the common rabbit worth, say, five guineas, and a seal-skin jacket worth, perhaps, ten times the amount.

After dyeing, all skins must be carefully dried and cleaned to get rid of any mechanically adhering dyes. When taken from the dye-bath, they are allowed to drain, washed in clean water, again allowed to drain, and the excess of moisture got rid of by means of a hydro-extractor, which is merely a cylinder with perforated sides revolving at a high rate of speed about a vertical axis. The centrifugal force causes the water to be driven outwards, and the skins are then partially dry. The drying is completed in drying-rooms or stoves heated by steam-pipes, and here great discretion is required, as, if the heat is too great or the process too hurried, both pelt and fur may be injured in quality, and the latter in colour. In order that they may dry flat, some goods are *nailed*—that is, placed on flat boards and nailed round the edges after a moderate amount of stretching. Others are merely stretched and allowed to dry slowly. To some, it is advisable at this stage to apply substances which keep the pelt soft and supple on drying, but this is not necessary in all cases, as much depends on the manner in which the skins are first dressed.

When dry, the skins are cleaned. This is accomplished by placing them in sawdust in a revolving drum of the type previously described. The length of time during which they must be *drummed* varies enormously, and depends largely upon the nature of the materials employed in dyeing. For some skins one hour is sufficient, others require twenty-four hours or even longer. When judged to be clean they are *caged* to remove the dust, and then passed to the finishing department. Here they are beaten with canes to free the under-wool from felt, the pelts damped, and the skins stretched and *knifed*—that is, pulled backwards and forwards over a blunt flesher's knife. This softens them, and makes them pliable, so that the fur lies evenly and "flows" under the hand.

Finally, the fur is *set*, or brushed with a damp brush in the proper direction, so as to straighten any hairs that may have got twisted and laid out of position.

Here the dyer's work comes to an end. From him the skins pass to the merchant, who disposes of them to the furrier, or direct to the furrier, who makes them into the thousand and one articles for which there is a demand.

There are several processes used by the fur dresser and dyer which have not hitherto been mentioned. Some of the more important ones will be here described.

Shaving and Sleeking. The pelts of some skins intended for use as garments are so thick that unless a portion of the leather is removed the finished article would be uncomfortably heavy to wear. To remedy this defect the pelt is *shaved*. To perform this operation the skin is laid over a shaver's beam, which is similar to that employed by the unhairer, except that it is flat instead of being convex outwards, and by a series of downward pushing strokes layers of leather are stripped off, and the whole brought to a level surface of even thickness. To do this the skins must be sufficiently moistened, and the knife used of a special kind. Figure **1***h* shows one of these cross-handled knives. The edge is turned backwards and kept very sharp.

9. SPECIMENS OF HAIR SEALS
a. Whitecoat *b.* Blue-back *c.* Common Seal

In **7** two *shavers* are seen at work on dyed whitecoats. The pelt, before shaving, is discoloured by the dyes used, and where the knife has passed over the pelt the white unstained leather is to be seen. Each shaver holds between the first and second finger of his right hand a small steel [**1c**], with which he sharpens the turned-back edge of the knife.

Various mechanical contrivances have been devised with a view of replacing this manual work, but so far no process causes so little damage to the skin or gives such a good result as this one just described. All seals, including fur seals, bluebacks, hair seals, and whitecoats, are shaved, and sometimes heavy-pelted skins like wallaby undergo the same treatment.

Sleeking is a process adopted in order to soften and make smoother the skins which are dressed with a heavy pelt such as goats. The skin is laid out, pelt uppermost, upon a flat table, and the *sleeking knife* [**1d**] pushed over it. Inequalities are removed, and the friction also causes a certain amount of softening.

In fur seals, after dyeing, there are to be seen short, stiff hairs which escaped the unhairing and pulling knives. These, if allowed to remain give to the skins an unpleasant *handle*—that is to say, they feel harsh when the hand is passed over the fur. In order to remove these, various types of machines have been devised. One of the earlier instruments was so constructed that the skin was stretched over a bar, the fur blown back and held down while the stiff, upstanding hairs were burnt out at the roots by means of an electrically-heated wire. In a later and improved pattern the hairs, instead of being burnt out, are cut off by the scissor-like action of two blades which are moved after the fur is blown downwards and held in position by two combs. By a system of gearing the skin is caused to move forward a fraction of an inch immediately after the release of the blades from the cutting position, so that every part of the skin is in turn subjected to this process.

Even then, certain hairs, known as *stage hairs*, are left, and these are removed by a pulling instead of a cutting action in a machine of somewhat similar construction, known as a *stageing machine*. The process of machining is essential for many skins, though there is an unavoidable removal of some of the fur which tends to make the skin poorer in quality.

Shearing. For some purposes, such as the manufacture of glove tops, fur for covering ladies' hats, etc., it is usual to take certain kinds of skins and by shearing off the top hair secure a shorter fur with an even surface. This is largely done in the case of white Polish rabbit, Russian hares, and some skins which, when dyed and shorn, resemble furs of a shorter staple.

The skin is fastened to an endless band in the shearing machine which passes over rollers. The tips of the hair come against a knife over which passes a set of blades set round a cylinder. This cylinder revolves at a high rate of speed and cuts off the tips exactly as grass is cut by a lawn-mower. Attached to the machine is a pipe connected with some arrangement for creating suction, by which the loose fur is carried away.

In addition to these processes there are others which are of use in various departments. For example, some skins can be mechanically brushed and beaten, and in such cases manual labour is dispensed with.

In connection with the subject of the dressing and dyeing of furs, it must be remarked that there are probably few branches of industry where experience counts for so much as in this one. To become a successful dresser, and perhaps still more so in the case of the dyer, great patience must be exercised in the acquiring of details concerning the methods to be employed for each particular class of goods. No two parcels of goods can be treated in the same manner; each requires careful consideration and must be treated according to its merits. Unceasing watch must be kept lest at any one of the many stages mistakes should be made, lest skins should be kept too long in a moist state, or the drying should be hurried.

Formerly, as in the drying of textiles, rule of thumb methods were the fashion; but the old order has changed and is yielding place to new. Science, the handmaiden of all arts and industries, is beginning to take her rightful place, and in consequence new methods are being introduced, and better and more constant results are to-day attainable.

The Manufacture of Fur Articles.

From the fur dresser and dyer the finished skins pass to the furrier, whose work consists in making them into articles for personal and domestic use. This work may be divided into several divisions, and though an experienced furrier is capable of executing the whole of the work, most firms employ men for each department.

Let us suppose that a lady's sable set is required. The skins to be used are carefully sorted and matched according to colour. A pattern in paper is usually made and the skins laid over this in order to see how many are required. The furrier then cuts off legs, tails and heads, as well as any bad patches on flank or belly. Should there be small bare patches in the skin they are cut out, a V-shaped cut being made from the pelt side, and the edges again sewn together. In this process of cutting, a knife of peculiar pattern is used. One is shown in **1b**, and will be seen to consist solely of a blade. It is held with the blunt end in the hollow between thumb and first finger, by the thumb and second finger, while the first finger is curved over the blunted circular back of the knife.

It is necessary sometimes to match different parts of the skin. For example, in sewing together two sable skins, head of one to rump of the other, there would be considerable inequalities in the surface, so that it may be advisable to remove a portion of the rump in order to get a more even surface. Again, two skins, A and B, stitched side by side, may be of slightly different colour or fulness. Accordingly, they are cut down the centre of the back, the left-hand half of A is stitched to the right-hand half of B, then the remaining halves are sewn together and the two composite skins sewn as required. By this means a more even article, both in surface and colour, is obtained than would be possible if the skins were merely sewn together.

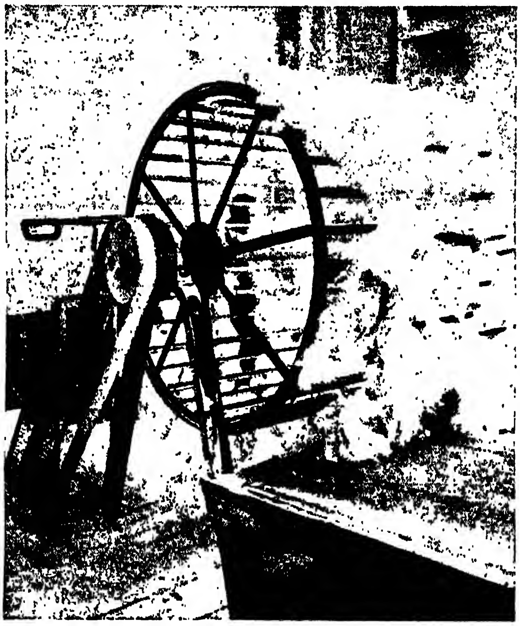
After cutting away all undesirable parts of the skin, and the process just described, the skins are sewn together. For this purpose a special machine is used. It consists essentially of a needle travelling horizontally, which just clears the surface of two circular discs or shallow cylinders placed in the horizontal plane and touching tangentially. These discs are kept together by a spring which can be released at the will of the operator. In using the machine, the two edges which are to be sewn are brought together between the discs above-mentioned and held there after any upstanding fur has been placed in position by means of a blunt needle or other object. When ready, the machine is set in motion—they are usually driven by a foot-treadle—and as the discs revolve, the skins travel on and the needle passes through both skins forming the stitch, and at the same time locking it.

"Nailing." When the various pieces are sewn together, the whole must be stretched so as to make the seams lie flat and to bring the piece to the shape required. To effect this, the process of *nailing* is necessary. For a flat article such as a tie or coat-lining, the skins are moistened on the pelt side, stretched out on a flat board, fur side downwards, and small nails driven in at the edges. For muffs a block is used, generally made in three pieces, which fit into one another by means of a tongue and groove. The skins are stretched round the block and nailed securely round the edges; sometimes several parallel rows of nails are also driven in in order to keep the skins straight.

The articles are allowed to dry on the nailing board or block and are then removed. Where a block has been used, the nails are drawn and the centre piece of the block taken out. This allows the muff to be easily taken off without altering the shape. Next comes the process of lining. Silk, satin, or other material is employed, and between it and the fur a layer of cotton-wool or wadding is placed. This serves a double purpose—that of increasing the thickness and so making it more serviceable as a defence against cold, and also that of making the muff or other article feel *fuller* and softer than it would otherwise do.

Linings and Rugs. A large part of the furrier's work consists in the manufacture of fur linings for coats. The skins are matched as far as practicable for colour and quality, and the processes of cutting and nailing carried out. Sometimes this work is done in the countries from which the skins are obtained—as, for example, the dog robes from China, or the kid crosses and kid leg crosses from the same country. Marmot skins are occasionally made up into linings, which are sold under the name of marmot robes.

The chief furs which are made into linings are musquash, opossum, hamster, kaluga (or susliki), squirrel back and squirrel belly (or squirrel lock, as it is generally called), mole, and mink.



10. DRYING OSTRICH FEATHERS ON A WHEEL

Rugs are made from skins which are best adapted for the purpose for which they are required. Vicuna, guanaco, and raccoon are largely used for carriage rugs, while for hearthrugs, bear, wolf, goat, dyed either black or bear colour, and sheep skin are most frequently used.

Seal Skins. In order to summarise the various processes which are necessary to convert a raw skin into a finished article, it will be convenient to take the sealskin as an example, and to describe in their proper sequence the different operations which are performed.

The seals are killed either on the beaches or in the open sea. In the latter case they are sometimes speared, but it far more frequently happens that they are shot. When taken on land, care is required in the stages prior to the killing. On the Alaskan Islands the bachelor seals, or *holluschickie*, as the natives call them, of ages varying from two to seven years, are driven from the seal beaches to the killing grounds. This must be accomplished slowly, or the animals become heated, and the fur rubs away at the least touch. They are driven in herds, and on arrival at the place of slaughter are stunned by means of blows on the head delivered with heavy wooden clubs. A sharp knife is plunged between the fore flippers right into the heart, to kill the seal and to prevent further *blood heating*, as it is called. As soon as possible the animals are skinned, and every available piece of skin is removed, and only little patches on the upper and lower lip and tail are left. The skins, with their thick coat of blubber attached, are taken to the curing-house, laid in piles, fur to pelt, and salt plentifully applied to the flesh side. After remaining for about three weeks, they are rolled and corded, and sent for shipment, and it is in this state that they arrive in London. They are then sorted according to size and quality, and put up for sale by public auction.

From the saleroom they pass to the dresser and dyer, whose work it is to change the unsightly objects into a presentable skin. The first work to be done is the removal of the fat or blubber, after which process the skin must be washed with various cleansing materials, then dried as already explained.

The "Unhairing" Process. The next process is that of *unhairing*. By damping the skins and quickly drying at a comparatively high temperature, the hair is loosened while the fur remains unaffected. The unhairer then proceeds to remove all hair, as far as is possible, first with the unhairing knife and then with his pulling knife.

At this stage the fur presents a curly appearance, and is yellow to grey-brown in colour. From the unhairer they pass to the dresser, who greases, mills, and cleans them, and prepares them for the dyer. It is important that all grease should be removed from the fur, as if this is not done the dye is not properly absorbed, and an uneven and patchy colour is the result, with a depreciation in value.

On receiving the dressed skins, the dyer combs out the fur, and proceeds to apply the various mordants and colours. This is always done by brushing, because by this means the curl is taken out of the skin, and also the pelt is less injured than if the skins were dipped in the dye liquor. Between each operation of brushing—and there are many of them—the skins are allowed to dry, and are then beaten to get rid of dust from the materials which have been employed.

When the dyeing operation is completed, the skins undergo a thorough cleaning in sawdust to make the fur bright and soft, and to remove all traces of the dyestuffs from the bottom of the wool, where it is apt to lodge. This is necessary in order that the skins may feel soft and full to the touch. If dirty, they feel somewhat harsh, and the fur does not flow easily when the hand is passed over it.

Preparing the Pelt. Attention to the pelt is now required, as it is thick, heavy, and almost black from long contact with colouring matters. To alter this state of things the skins are handed over to the shaver, who moistens them and then shaves down the pelt to an even thickness. In doing so, he

takes off the outer discoloured layer and leaves the pelt almost white—generally tinged with yellow.

After drying, the skins are carefully examined in order to pick out any that require *machining* and *stageing*. During these various processes the fur may become slightly disarranged. Certain portions may be twisted, and, by the weight of skins above—they are always folded down the middle, pelt outwards, and laid in piles—*print marks* are produced. These spoil the appearance of the skin, and are got rid of by the process of *setting*. The fur is brushed with a soft brush, moistened with either plain water or a weak solution of various substances, and then allowed to dry.

The skins are now finished, and are sent back to their proper owners. The merchant disposes of them to the furrier, who proceeds to manufacture from them jackets, capes, or other treasures so dear to the feminine mind. The furrier, instead of employing his own permanent staff, may hand the skins to a *chamber-master*, who is required to make so many articles from the skins provided. This practice is less common than formerly, as most furriers prefer to have the work done under their personal supervision. The processes already described are employed, the skins are cut, nailed to shape, and the pieces sewn together. Then the linings and padding are added, and the garments pass to the retailer, who supplies the public needs.

FEATHERS

Feathers, like hair and nails, are products of the epidermal portion of the skin.

A feather consists of three parts: (1) A *barrel*, or *calamus*, which is the hollow, translucent part used for writing; (2) a *shaft*, or *rachis*, which is opaque and filled with pithy substance (this is roughly quadrangular in transverse section with a longitudinal furrow along its inner side—that is, the side turned towards the body; the rachis, together with the calamus, form the quill); and (3) the *barbs*. These are subdivided into *barbules*, and the latter again into *barbicles*. The barbs and their subdivisions constitute the web or *vane*.

11. STEAMING OSTRICH FEATHERS BEFORE CURLING

Feathers are of different nature according to the parts of the body in which they occur. The contour feathers, or plumes, come chiefly from the wings and tail, and are the most important for ornamental purposes. Besides the plumes there are smaller, softer feathers, which are classified into downs, half-downs, and hair-like feathers. Finally, there are the small nesting feathers.

The plumes are the largest of the feathers, and sometimes show magnificent markings and colourings, as in the case of the peacock and pheasant. The downs, on the other hand, are covered by the plumes, and are smaller, more fluffy, and more numerous. In aquatic birds—especially in those inhabiting high latitudes—the fluffy down is highly specialised, and is so elaborate as to form an important feature of the plumage.

Uses of Feathers. The principal uses to which feathers are applied are these:

1. The manufacture of bedding, cushions, etc.
2. Ornamental and decorative purposes.
3. The manufacture of pens, toothpicks, light brushes for dusting and other domestic purposes.

Sometimes not only the feathers but the whole bird is used as an ornament. This is notably the case with birds of paradise and various tiny humming-birds. In other cases some part of the bird—for example, the wing, or the head and neck—is employed, while frequently the long contour feathers are plucked out and used.

The list of birds which serve for ornament is a long one. Among them are:

Birds of paradise:	Jungle cocks
Black	Kingfishers
Green	Merles
King's	Orange oriels
Bustards	Osprey
Crested pigeons	Ostrich
Grebe	Peacock
Heron	Pheasant:
Humming-birds:	Common
Amethyst	Japanese
Emerald breasted	Seagulls
Ruby	Starlings
Indian crows	Terns

There are others, but these are the more common.

Of the feathers usually seen, the best-known are those of the ostrich, while the most valued are those of the egret. The real home of the ostrich is Egypt and the North African States, and these countries still provide a certain quantity. The bulk of the supply, however, comes from South Africa, where the birds were introduced some thirty or forty years ago. The rearing and farming of ostriches have been attended with such marked success that the killing of wild birds has been almost, if not quite, abandoned. The profits from ostrich farming vary from year to year, and are determined by two main factors—namely, supply and demand, depending upon the dictates of fashion, and the prevalence of disease, to which the birds are particularly liable unless allowed practically unlimited space in which to roam.

The birds are clipped every eight months, and each yields an average of about 20 ounces. The first crop consists of chicken feathers, which are known commercially as *spadonas*.

The ostrich feathers are sold by public auction in London, and for the last five years the quantity sold has averaged about 600,000 pounds per annum. This represents an annual value of £1,200,000 to £1,500,000. About nine-tenths of the total amount comes from South Africa.

The raw material is then distributed for manufacture to various parts of England, France, Germany, Austria, and the United States of America. The main processes of manufacture are known as

dyeing and bleaching, laying or preparing, sewing and curling and finishing [10,11]. In addition to the manufacture just mentioned, there is a large industry connected with the making of boas and feather trimming.

Ospreys. Egret feathers, known to the trade as ospreys, are taken from the long-winged birds of the heron family. In character they are exceedingly soft and silk-like, yet remarkably stiff. The barbs are very fine, long, and filiform. These are largely used as ornaments for the hair, generally in conjunction with diamonds. The price is exceedingly high, sometimes reaching as much as £8 per ounce.

Considerable feeling has been shown by humanitarians concerning the slaughter of these birds, which are usually killed during the nesting season, as the plumage is then at its best. It is recorded, however, that egrets flourish in confinement, and that the feathers taken from such birds are of just as high a quality, and command the same prices, as those taken from wild birds. It is possible that this industry may be developed so that the reproach of wearing "murderous millinery" may be taken away from those who decorate their hair with these beautiful feathers.

Plumage of many different kinds is collected in country districts, and from poulterers in England and the various countries of Europe, and the manufacture of these constitutes a very considerable industry. Another branch of the feather trade is fan-making. In this ostrich feathers are largely employed, though at present these articles are not much in vogue.

Preparation of Feathers. The preparation of feathers consists mainly in the cleaning and dyeing of them. It is usual to dye only those which are intended for ornamental use in boas, trimmings, ladies' hats, etc., but in the case of all feathers a preliminary cleaning operation is necessary, since when taken from the bird they are impregnated with various substances, such as blood and natural grease, which, unless removed, would undergo decomposition.

Bed Feathers. For the making of beds, feathers are taken from the domestic fowl, ducks, geese, swans, etc., and the best of them are plucked from the living birds in spring. This kind is preferred to those taken from the body after death, as they are cleaner, freer from blood and animal fats, and less liable to become tainted. They are also rather more springy and elastic, and so better adapted for this particular purpose.

The feathers are first dried in stoves by means of hot air, and then beaten with sticks to render them free and light. The dust is removed by shaking them in sieves, and the feathers are then ready for the manufacturer.

For bed quilts the down of the eider duck (*Somateria mollis*) is unequalled, because in addition to its extreme softness it possesses the property of great lightness. The down is supplied by the female, who, while sitting, lines her nest and continually adds to the warm, soft lining, so that by the time the young are born there is sufficient down to cover them completely during her absence. Each nest yields about one-sixth of a pound of down, valued at 12s. to 15s. per pound.

Quills. Like the down used in the making of feather beds, the best feathers for quill-making are taken from the living bird in spring. The most suitable, and at the same time the most expensive, feathers are obtained from the swan, but large quantities of quills from the albatross, heron, pelican, hawk, owl, etc., are used. For fine work, feathers of the crow are employed, but the main source of supply is the goose, which, in certain parts of Europe, is bred almost entirely for this purpose. To all these feathers the following treatment is applied.

The feathers on removal from the body are heated, in a bath containing fine sand, to an average temperature of 60° C. A portion of the grease and other adhering foreign materials is thereby softened and partly absorbed by the sand, while the remainder is removed by scraping the still warm and pliable feathers. If desired, any pattern or design may be then impressed; on cooling, the quill is left as a dry, horny substance, ready for cutting to the shape of pens, toothpicks, etc.

Feathers for Ornamental Use. The feathers intended for millinery purposes are first sorted according to quality and colour, the best colours and the purest whites being retained for use in the natural state after they have been subjected to proper cleaning. Those which are not to be dyed are washed in hot water in which soap has been dissolved. This removes grease and other objectionable matter. After this process they are thoroughly rinsed in warm water, and those that are to be kept white are then bleached. Formerly this was always effected by moistening the feathers and placing them in closed chambers where they were exposed to the fumes of burning sulphur. Now, however, hydrogen peroxide is largely employed as a bleaching agent. It is more convenient to use, and possesses the further advantage of leaving a purer and more permanent white. Feathers and other articles that have been "sulphured" are apt to return to their original yellow tint on long exposure to the atmosphere, or on coming into contact with any alkaline material, such as soap. Bleaching with hydrogen peroxide is not open to this objection.

Even after this treatment some feathers retain their yellowish cast, and to correct this defect they are often dipped into a dilute solution of indigo or some other blue dyestuff. This process is based upon the same principle as the one adopted by the laundress in "bluing" linen after washing, for the added blue neutralises the yellow, leaving a much purer white.

Feathers the colours of which are unsuitable for natural use are dyed. Dyestuffs such as logwood and indigo are much used, though a far wider range of colours is afforded by the various so-called aniline dyes, artificial colouring matters derived from coal-tar products.

Before dyeing, the feathers must be well cleaned with soda in order to get rid of every trace of grease, and then carefully rinsed to remove the alkali, which would otherwise affect the ultimate colour. According to the dyestuff chosen, the treatment must be varied, since some—for example, malachite-green, auramine, magenta, methyl-violet—require a neutral bath, while others must be used in a bath made acid with either sulphuric or acetic acid. After dyeing, the feathers are well washed, and then carefully dried in revolving drums.

Curling. After dyeing, the feathers usually require a certain amount of curling. This is effected by pulling them over a blunt knife, or by the cautious application of a hot iron. Some plumassiers employ various curling liquors, with which they moisten the feathers before dyeing. These liquors frequently contain small quantities of ammonia, and in some cases substances of a gumlike nature are added to fix the curl.

Casting and Forging Scissor Blades. Hafting-Knives and Forks, and the Various Materials Employed.

THE MAKING OF SCISSORS

Scissors. Scissors differ widely in regard both to material used and in methods of manufacture, both being controlled by the price paid. The best are made entirely of crucible-cast steel. Large ones have bows of wrought iron welded to steel blades. The majority of German-made scissors are cast instead of being forged, in consequence of which the hand-hammering that toughens and consolidates the forged steel blades is sacrificed.

Scissors possess a peculiar and special interest, because they are a very remarkable type of cutting implement. They represent an immense group, which includes not only scissors but the shears of all kinds employed in many industries and manufactures, up to and including those which sever cold plates of steel 1½ in. thick. All alike operate as shears, in which two blades pass over each other in the same plane. The cutting edges are blunt by comparison with those of knives and chisels. An angle of from 30 to 40 degrees is included between the face and the edge, which alone is reground, or sharpened. These edges also fulfil the function of supporting the material that is being severed.

Now, the peculiarity is that scissor-blades are so designed that the material shall be supported by them instead of becoming folded down between the blades, as it does sometimes in poorly made instruments. So delicate is the formation, and so finely have the adjustments to be made, that the best scissors are hand-made from beginning to end.

The Mechanics of a Pair of Scissors. In the first place, the blades are not flat. Holding up a closed scissors to the light, it is seen that the blades only touch at the screw and at the point. They are concave, and they overlap slightly at all cutting positions, and therefore cut only at one spot at a time. In the second place, the blades do not fit tightly at the screw when they are opened at right angles. Only as they close for cutting do they tighten, because slight elevations on each, the "riding parts," by their mutual contact cause the edges of the blades to come into successive contact as they are closed for cutting. Then finally there is the hollow grinding of the faces in the transverse direction, which affords a slight "clearance" to the cutting edge, and so ensures freedom from useless friction.

Scissor Forging. The scissor blade is forged roughly from the bar of steel by hand [4], or it is stamped in dies. If it is of large dimensions, a piece of wrought iron is welded on for the bow or loop, but, if small, the smith punches a small hole in the end of the forging which is to form the bow. Then very deftly he opens out the hole, and, inserting in it a "form" or special anvil block, he enlarges the hole by hammering [5], and in this way forms the bow in one piece with the blade. The blades are thus sent to the man who makes up the scissors.

Although the occupation of the hand-forger is not yet gone, it is lessening. In all the foremost factories scissor-blade forging is now largely taken by the belt drop stamps and power hammers. Half the impression of one half of the scissor is cut in solid steel dies, one of which is attached to the tup or head of the drop hammer, and the other to the anvil below. Three blows on a piece of red-hot steel bar suffice to forge one side of a scissor. The surplus steel thrown out forms an irregularly shaped "fash" or "fin" around the outlines, including the bow. This is removed in a stripping die—that is, a die pierced to the exact outline of the scissors, but cut right through, with some taper in the downward direction. Scissor blades stamped thus are produced in two or three seconds, wholly of steel, with no weld for the eye, nor with any laborious opening out of the eye by hand-hammering.

Making up. The first task of the man who makes up or assembles the scissors after their filing [6] and grinding is to put the blades together. He first drills a hole to receive the screw [7]. This has three diameters, comprising the largest portion at the top into which the head of the screw sinks; the intermediate size in which the screw fits freely, but without any slack, and the smallest, entering the hole in the lower blade into which the point fits tightly.

At this stage the blades are hardened and tempered. The colour for tempering is a mottled brown, or a purple, according to the size. Some delicate manipulation follows, termed "setting," by means of which the blades, being dealt with separately, are hollowed with judicious hammer blows, both longitudinally from the rivet to the point and from the back to the edge. The object of doing this is to ensure that the scissors shall cut at one spot only, for, as already explained, if they lay flat face to face, they would not cut. The experienced skill of the craftsman is the only guide through which the sweet cutting of the scissors is ensured. Afterwards the blades are ground, and the bows are filed [8] and burnished. The blades are then screwed or riveted [9] together permanently.

The numerous shear-like tools and single-bladed cutting ones each absorb the labour of distinct departments. But much of the essential handicraft described applies to all. Large blades, whether those of shears, scythes, and large knives, only have their cutting portions of steel, welded to a wrought-iron backing. Methods of forging, tempering, and grinding are modified with conditions.

Hafting. We have left the hafting of knives to be treated alone in order to keep the cutler's steel-work distinct from operations that are of a wholly different kind. Ivory, the most valuable material, has, by reason of the diminution of the supply, become too costly for any but the most expensive cutlery. Horn is employed extensively, and mother-of-pearl, tortoiseshell, ebony, bone, German silver, brass, aluminium, alloys, xylonite or celluloid, and other materials sometimes. The subject has two aspects—that of the preparation of the materials, and that of the methods by which they are attached to the steel goods.

Ivory. When this is employed it is obtained chiefly from the tusks of the African elephant. The high cost of the material, ranging now to £90 per cwt. for the best tusks, renders the greatest

economy in cutting imperative. The difficulty of cutting is increased by the curved form of the tusk, which seriously interferes with getting long, straight pieces out of it; by the fact that it is hollow for about one-half its length from the base; by its elliptical section when cut across, and by the presence in some cases of cracks, and occasionally, too, of damage inflicted by rifle-balls. So that before any cutting is done the tusk is very carefully marked out on the end, both in reference to the cross section and to the length of the cuts, and in order to utilise the material to the best advantage for the specific purposes for which the ivory is required.

Generally the tusk is cut tangentially—that is, in slabs parallel with the diameter or axis—both to economise the material and to secure the best and finest appearance of the grain. If tapered handles are wanted, as in table knives, they are sawn out of one another—that is, alternate thick and thin edges lie adjacent. A very thin frame-saw or circular saw [10] is used, worked by hand, and lubricated with tallow in order that as little material as possible shall be wasted in dust. Ivory requires to be seasoned similarly to wood. It is affected by atmospheric influences, shrinking chiefly in width, with dryness, and cracking in a dry atmosphere.

Xylonite. Xylonite, or celluloid, is an excellent imitation of and substitute for ivory. The characteristic grain of ivory is absent, but only a close scrutiny enables one to distinguish between the two. It consists of a solid solution of the lower nitrates of cellulose (a component of vegetable tissues) in camphor. Celluloid is plastic at 125° C., a property which renders it highly valuable not only to the cutler but in many other industries. Pieces can be cemented together by simple pressure at this temperature. It is also easily cemented to metal, wood, leather, etc., by the help of collodion, or of a solution of shellac and camphor in alcohol. In handling knives with this, after the handles are bored they are soaked slightly in hot water, and driven on the tang by a hammer. The tang is usually serrated to afford a better grip than plain edges would give. Xylonite will adhere to a properly made tang without either a through-tang or an edge pin.

Horn, Bone, and Shells. Stag-horn is used extensively, most of it being imported from Germany. But the horns of oxen are also employed, being imported chiefly from abroad—from South Africa, India, and South America. The stag-horn is preferable. The central parts are spongy and cellular, and the horn is therefore only retained intact when short pieces are used entire, as in carvers. In other cases the horn is cut up with a saw, and is finished to shape by filing. The rough exterior is left in its natural state, as being suitable for affording a grip to the hand.

The treatment of bovine horns is different, because they consist almost wholly of animal matter, while the stag-horn more nearly resembles bone. The ox-horns are treated by maceration in water, in consequence of which they are detached from the bony cores which project from the forehead, and around which the horns are deposited in annual layers. After the tip has been sawn off, the remainder is softened by immersion in boiling water and then held in the fire, by which it is softened so much that it can be slit down one side and opened out flat, when it is squeezed between plates of iron or wood. Afterwards the material is treated according to the specific purpose for which it is intended. The plastic property which it possesses is due to the presence of gelatine, which acts as a natural cement, and without which the horn would be brittle.

For the handles of knives the prepared horn is sawn into suitable sizes, and, being warmed, is roughly shaped with the knife, and finally pressed in moulds or dies. The horn and the dies are dipped in boiling water and screwed together, and left to cool and set. Horn is dyed to imitate tortoiseshell by treating it with infusions of pearl-ash, quicklime, and litharge, dragons' blood and water, the details of which need not be explained.

Bone is used only in cheap cutlery, becoming brittle and discoloured with age. The shin-bones of the ox and those from the bullock are used. Being largely impregnated with oil, they have to be boiled and bleached. In this process they lose a portion of their gelatine, and acquire some brittleness. Bone is rather hard to saw and work. When finished, it is whitened by being soaked in turpentine, boiled in water, and polished with whiting and water.

Mother-of-pearl is obtained chiefly from the shells of the pearl-bearing oyster of the Indian seas, but other bivalves are laid under contribution. The shells can be sawn and filed, but the brittle porcelaineous shells cannot be treated in this way. They can be split into leaves for the handles of knives, though this is too risky to be often adopted. They are readily cut with a hack-saw, and are ground on a wet grindstone.

The plates of a marine tortoise or turtle are also employed for knife handles. The largest plates measure about 12 in. by 8 in. by about ¼ in. thick in the centre. The material is treated similarly to horn. They are dipped in boiling water to temper them. Tortoiseshell can be cut and cemented when softened in boiling water. Plates of metal, as nickel and brass, are also used for handles, and some woods, as ebony and boxwood.

Hafting Table-Knives. The drilling of the handles of ivory or celluloid is done by hand. Machine drilling has been tried, but does not give so good results as hand. If the hole is slightly out of centre, the tang shows as a dark line on one side, which condemns the handle. An ordinary drill is used, 5-32 in. diameter, very sharp, and running at 1500 to 2000 revolutions per minute, and driven by a narrow belt from below. The drill shank carries a bobbin for the belt, and it is supported in two forks set up on the bench. The workman holds the blank on his knee, and moves it towards the drill. He only drills about half an inch at a time, using oil on the drill, and turning the handle over at each interval until the hole is through the handle, or only partly through, according to the method of hafting adopted.

Forks and spoons are among the products of the cutler. Both are stamped from sheet metal. This is supplied rolled to the gauge required. It is then cross-rolled to form the handles, and the prongs of the forks, and the bowls of the spoons. The shape is next stamped in dies. Afterwards the edges are trimmed by hand-filing. The instrument, being now ready for electro-plating, is chemically cleaned, and dipped into a solution of mercury in nitric acid, ready to receive the preliminary coat of silver. A scratch-brushing follows, when the full coating is given in the "dead" vat. Immersion in the "bright" vat follows, succeeded by a rinsing in hot water, polishing, and cleaning with rouge. JOSEPH G. HORNER

MAKING SCISSORS AND KNIFE HANDLES

4. HAMMERING A SCISSOR-BLADE OUT OF A PIECE OF STEEL

5. SHAPING EYES OF SCISSORS ON A SPECIALLY SHAPED ANVIL

6. ROUGHLY FILING A BLADE BEFORE THE HARDENING PROCESS

7. DRILLING THE HOLES INTO WHICH THE RIVET IS INSERTED

8. FILING AND SHARPENING THE BLADES OF A PAIR OF SCISSORS

THE OPERATION OF RIVETING THE BLADES TOGETHER

10. SAWING UP ELEPHANTS' TUSKS FOR IVORY KNIFE-HANDLES

11. CEMENTING THE TANG OF A BLADE INTO ITS HANDLE

12. SMOOTHING AN IVORY KNIFE-HANDLE ON A BUFFING MACHINE

Harder Examples in Factors. The Remainder Theorem used in Factorising Multinomials. Highest Common Factor and Lowest Common Multiple.

THE REMAINDER THEOREM

HARDER FACTORS

63. We shall now work a few miscellaneous examples in factors.

Example **1.** Find the factors of

$$(x^2 + 5x)^2 - 8(x^2 + 5x) - 84.$$

This is equivalent to $y^2 - 8y - 84$, if we suppose $x^2 + 5x$ to equal y. The factors of the latter expression are $(y + 6)(y - 14)$.

Hence, we have

$$\begin{aligned}&(x^2 + 5x)^2 - 8(x^2 + 5x) - 84\\ &= (x^2 + 5x + 6)(x^2 + 5x - 14)\\ &= (x + 2)(x + 3)(x + 7)(x - 2)\ \underline{Ans.}\end{aligned}$$

Example **2.** Put into factors

$$(x + 3)(x + 4)(x + 6)(x + 7) - 40.$$

This is easily reduced to the form of Ex. **1**. For we notice that $(x + 3)(x + 7)$ gives $x^2 + 10x + 21$, and $(x + 4)(x + 6)$ gives $x^2 + 10x + 24$, so that each product contains the terms $x^2 + 10x$. We therefore treat $x^2 + 10x$ as if it were a single term, y. Thus

$$\begin{aligned}&(x + 3)(x + 4)(x + 6)(x + 7) - 40\\ &= (x^2 + 10x + 21)(x^2 + 10x + 24) - 40\\ &= (x^2 + 10x)^2 + 45(x^2 + 10x) + 504 - 40\\ &\quad [\text{since } (y + 21)(y + 24) = y^2 + 45y + 504]\\ &= (x^2 + 10x)^2 + 45(x^2 + 10x) + 464\\ &= (x^2 + 10x + 16)(x^2 + 10x + 29)\ [\text{See Ex. } \mathbf{1}]\\ &= (x + 2)(x + 8)(x^2 + 10x + 29)\ \underline{Ans.}\end{aligned}$$

Example **3.** Find the factors of

$$(y + z)(z + x)(x + y) + xyz.$$

The product of $(x + y)$ and $(x + z)$ is

$$x^2 + (y + z)x + yz.$$

Hence, the given expression

$$\begin{aligned}&= (y + z)\{x^2 + (y + z)x + yz\} + xyz\\ &= x^2(y + z) + x(y + z)^2 + yz(y + z) + xyz.\end{aligned}$$

The first two of these expressions contain a common factor $x(y + z)$, and the last two contain a common factor yz, so that we proceed as in Art. **55** and obtain

$$\begin{aligned}&x(y + z)\{x + (y + z)\} + yz\{(y + z) + x\}\\ &= x(y + z)(x + y + z) + yz(x + y + z)\\ &= (x + y + z)\{x(y + z) + yz\}\\ &= (x + y + z)(yz + zx + xy)\ \underline{Ans.}\end{aligned}$$

Example **4.** Find the factors of

$$x^2(y - z) + y^2(z - x) + z^2(x - y).$$

Arrange the given expression in powers of x, and we get

$$x^2(y - z) - x(y^2 - z^2) + y^2z - yz^2$$

or

$$x^2(y - z) - x(y - z)(y + z) + yz(y - z).$$

It is now evident that $(y - z)$ is a factor of the expression. Thus, we have

$$\begin{aligned}&(y - z)\{x^2 - x(y + z) + yz\}\\ &= (y - z)(x - y)(x - z)\ \underline{Ans.}\end{aligned}$$

64. Rational Integral Expression. A result which is of great use in finding factors is that known as the Remainder Theorem.

Before enunciating the theorem we must define "a rational integral expression."

An expression is said to be integral when it does not contain a *letter* in the denominator of any term. It is said to be *integral with respect to any particular letter* when it does not contain that letter in the denominator of any term. Thus, $\frac{x^2}{3a} - \frac{2xy}{4b}$ is integral with respect to x.

An expression is *rational* when none of its terms contain square or other roots.

The Remainder Theorem. If an expression which is integral with respect to x, and rational, be divided by $x - a$, the remainder is equal to the result obtained by substituting a for x in the expression.

For the sake of shortness we shall use the symbol S_x to denote the expression which is rational and integral with respect to x. Thus, S_x may stand for some such expression as $x^4 - 7x^2 + 9$. Then the symbol S_a will stand for the result obtained by substituting a for x in this expression—*i.e.*, for $a^4 - 7a^2 + 9$.

Next, suppose we divide the expression S_x by $x - a$. The remainder, if there be one, will be of a lower degree than the divisor—*i.e.*, *the remainder will not contain* x. Suppose we denote the quotient by Q, and the remainder by R. Then, since

Dividend = Quotient × Divisor + Remainder,

we have

$$S_x = Q(x - a) + R \quad . \quad . \quad . \quad \text{(i.)}.$$

This result is true whatever be the value of x. It will therefore be true when x equals a. But, when $x = a$, the factor $x - a$ equals 0, and therefore the product $Q(x - a)$ equals 0. Also, since R *does not contain* x, it is unaltered by substituting a for x. Thus, the result (i.) becomes

$$S_a = R;$$

that is, the remainder is equal to the result obtained by substituting a for x in the given expression.

65. Again, if $x - a$ is a factor of the expression S_x, there will be no remainder when we divide S_x by $x - a$, *i.e.*, $R = 0$, and, therefore, $S_a = 0$.

Hence, *if, when a is substituted for x in an expression which is rational and integral with respect to x, the result is zero, then $x - a$ is a factor of the expression.*

Example **1.** Resolve $x^3 - 3x^2 - 13x + 15$ into factors.

If we substitute 1 for x in this expression, we obtain $1 - 3 - 13 + 15$, which equals 0. Hence it follows that $x - 1$ is a factor of the expression. By actual division we can find the other factor,

but a better method is as follows. Remember that our object is to find by what $x-1$ must be multiplied in order to obtain $x^3-3x^2-13x+15$. Clearly, if we multiply $x-1$ by x^2 we obtain the term x^3, but we also obtain $-x^2$. We, therefore, still require $-2x^2-13x+15$. In a similar way, if we multiply $x-1$ by $-2x$ we obtain the necessary $-2x^2$, but we also get $2x$. To make this agree with the given expression requires $-15x+15$, *i.e.*, $-15(x-1)$. Thus, we see that

$$x^3-3x^2-13x+15$$
$$=x^2(x-1)-2x(x-1)-15(x-1),$$

and that $x-1$ is a factor is now evident, the expression being

$$=(x-1)(x^2-2x-15), \text{ which, by Art. 57,}$$
$$=(x-1)(x+3)(x-5).$$

Example **2.** Resolve $x^3-2x^2-14x-12$ into factors.

In this case the result is not zero when we put $x=1$, or when we put $x=2$, or when $x=-1$. But, if we try $x=-2$, we obtain $-8-8+28-12$, which is equal to 0. Hence $x-(-2)$, *i.e.*, $x+2$ is a factor. The rest of the process is the same as in Example **1**. Thus

$$x^3-2x^2-14x-12$$
$$=x^2(x+2)-4x(x+2)-6(x+2)$$
$$=(x+2)(x^2-4x-6) \quad \underline{Ans.}$$

Note that it is useless to substitute values of x which are not factors of 12. For, if $x-a$ divides $x^3-2x^2-14x-12$, it is clear that a must divide the term 12.

Similarly, in Example **1**, we only need try factors of 15, *i.e.*, 1, 3, 5, 15, or the same values with negative signs.

EXAMPLES 18

Resolve into factors

1. $(x^2+2x)^2-11(x^2+2x)+24$.
2. $(x+1)(x+2)(x+3)(x+4)-48$.
3. $(x+2)(x+4)(x+5)(x+7)+8$.
4. $x^3(y-z)+y^3(z-x)+z^3(x-y)$.
5. $(b-c)^3+(c-a)^3+(a-b)^3$.
6. x^3+3x^2-6x-8.
7. x^4+4x+3.
8. $yz(y-z)+zx(z-x)+xy(x-y)$.

HIGHEST COMMON FACTOR

66. The Highest Common Factor, or H.C.F., of two or more algebraical expressions is the expression of highest dimensions [Art. **29**] which will divide each of them without a remainder.

67. The H.C.F. of simple expressions can be written down by inspection.

Example **1.** Find the H.C.F. of x^2yz and x^3yz^2.

The first expression is divisible by x and by x^2. The second is divisible by x, by x^2, and by x^3. Thus x^2 is the highest power of x which will divide both. Similarly, y is the highest power of y which will divide both, and z is the highest power of z. Thus the H.C.F. of x^2yz and x^3yz^2 is x^2yz.

Example **2.** Find the H.C.F. of $36a^2b^3c$, $24a^4b^4c^2$, and $27a^3b^2c$.

By arithmetic we find that 3 is the H.C.F. of the coefficients 36, 24, 27. As in Example **1**, the highest power of a which divides all three expressions is a^2, the highest power of b is b^2, and the highest power of c is c.

Hence, the required H.C.F. is $3a^2b^2c$.

Thus, to write down the H.C.F. of two or more simple expressions, we

(i.) Write down the H.C.F. of the numerical coefficients.

(ii.) Write down each letter which is common to all the expressions, and raise it to the lowest power in which it occurs.

68. The H.C.F. of multinomial expressions can be seen by inspection if we know the factors of the multinomials. We have only to write down each *factor* which is common to the expressions, and raise it to the lowest power in which it occurs.

Example **1.** Find the H.C.F. of x^2-x-6 and $2x^2-7x+3$.

We have

$$x^2-x-6=(x-3)(x+2)$$

and

$$2x^2-7x+3=(x-3)(2x-1)$$

Hence, the H.C.F. is $x-3$.

Example **2.** Find the H.C.F. of $8a^4+4a^3b-4a^2b^2$, $6a^3+18a^2b+12ab^2$, and $2ab(a^2-b^2)$.

Resolving each expression into factors, we get

$$8a^4+4a^3b-4a^2b^2=4a^2(2a^2+ab-b^2)$$
$$=4a^2(a+b)(2a-b)$$
$$6a^3+18a^2b+12ab^2=6a(a^2+3ab+2b^2)$$
$$=6a(a+b)(a+2b)$$
$$2ab(a^2-b^2)=2ab(a+b)(a-b).$$

The H.C.F. of the numerical coefficients 4, 6, 2 is 2; of the monomial factors a^2, a, ab is a; and of the remaining factors is $(a+b)$.

Thus the H.C.F. of the given expressions is $2a(a+b)$.

EXAMPLES 19

Find the H.C.F. of

1. $3abc^2$, $2a^2bc^3$, $5a^2b^2c^2$.
2. $4x^3y^2z$, $16x^2yz^3$, $10x^1yz^2$.
3. $21x^7y^3z^2$, $35x^3y^4$, $28x\,y^4z^3$.
4. $x^2-4x-12$, $x^2-3x-18$.
5. $x^2+3xy-4y^2$, $x^2+5xy+4y^2$.
6. $2a^2+5a-3$, $4a^2+4a-3$, $2a^2-5a+2$.
7. $6a^2+7ab-3b^2$, $4a^2+12ab+9b^2$, $10a^2+11ab-6b^2$.
8. $2x^2(x-2y)^3(3x+y)$, $4x^3(x-2y)(3x+y)^2$.
9. $12x^5+6x^4y-6x^3y^2$, $30x^3-105x^2y+45xy^2$.

69. H.C.F. of any Two Multinomials. By a method analogous to that used in Arithmetic [Art. **60** Arith., page 672] we can find the H.C.F. of *any* two multinomial expressions.

We can prove the same proposition for algebraical expressions as was proved for the two numbers in Article **59** of Arithmetic—*viz.*, *the common factors of a divisor and a dividend are the same as the common factors of the divisor and the remainder.*

Suppose A and B stand for two multinomials, having some common letter, x. Arrange A and B in descending powers of x, and suppose A is not of higher dimensions than B. Divide B by A; let Q be the quotient and R the remainder.

Then

$$B = AQ + R \quad . \quad . \quad . \quad . \quad (i.)$$

and, by transposing the term AQ we have

$$R = B - AQ \quad . \quad . \quad . \quad . \quad (ii.).$$

Now, a factor which divides both A and R must evidently be a factor of AQ + R also; so that from (i.) we see that it divides B. Thus, any common factor of A and R must also be a common factor of A and B.

In the same way, from (ii.) we see that any common factor of A and B must also be a common factor of A and R.

Clearly, then, the common factors of A and B are the same as the common factors of A and R.

If we now divide A by R, the H.C.F. of the new remainder and R will, exactly as before, be the same as the H.C.F. of A and R, *i.e.*, of A and B.

We have, therefore, only to continue the process of dividing the remainder into the previous divisor until we reach the stage where there is no remainder. The last divisor is the required H.C.F.

70. The above is only used to find the *compound* factor of the H.C.F. If the given expressions contain *simple* factors, these must be removed first [Art. **54**]. If these simple factors have any H.C.F., it is found by inspection, and multiplied into the compound factor found by the process of Art. **69**.

71. Remembering that the process is only used for finding the *multinomial* factor of H.C.F., and that each remainder contains the H.C.F. we are seeking, it is clear that we may multiply or divide any of the divisors or dividends by any *monomial* expression whenever the process of division renders this necessary. Instances of this occur in the second of the following examples.

Example **1**. Find the H.C.F. of $x^2 - 2x - 35$ and $x^3 - 3x^2 - 32x + 28$.

It is generally best to arrange the work in the manner explained in Ex. **2**, Art. **76**, page 935. of Arithmetic.

$$\begin{array}{r|r|r|l}
x+5 & x^2 - 2x - 35 & x^3 - 3x^2 - 32x + 28 & x-1 \\
 & x^2 - 7x & x^3 - 2x^2 - 35x & \\
\cline{2-3}
 & 5x - 35 & -x^2 + 3x + 28 & \\
 & 5x - 35 & -x^2 + 2x + 35 & \\
\cline{2-3}
 & & x - 7 &
\end{array}$$

Thus, the H.C.F. is $x - 7$.

Explanation. We divide $x^2 - 2x - 35$ into $x^3 - 3x^2 - 32x + 28$, the quotient being $x - 1$, and the remainder $x - 7$. This remainder is then divided into $x^2 - 2x - 35$, giving a quotient $x + 5$, and *no remainder*. Hence $x - 7$, the last divisor used, is the required H.C.F.

Example **2**. Find the H.C.F. of

$16a^4 + 4a^2 + 1$ and $8a^4 - 16a^3 + a - 2$.

$$\begin{array}{r|r|r}
 & 8a^4 - 16a^3 \qquad + \quad a - 2 & 16a^4 \qquad + 4a^2 \qquad + 1 \\
 & 4 & 16a^4 - 32a^3 \qquad + 2a - 4 \\
\cline{2-3}
a & 32a^4 - 64a^3 \qquad + \quad 4a - 8 & 32a^3 + 4a^2 - 2a + 5 \\
 & 32a^4 + 4a^3 - 2a^2 + 5a & 17 \\
\cline{2-3}
-17a - 8 & -68a^3 + 2a^2 - a - 8 & 544a^3 + 68a^2 - 34a + 85 \\
 & -68a^3 + 34a^2 - 17a & 544a^3 - 16a^2 + 8a + 64 \\
\cline{2-3}
 & -32a^2 + 16a - 8 & 21)84a^2 - 42a + 21 \\
 & -32a^2 + 16a - 8 & 4a^2 - 2a + 1
\end{array}$$

The H.C.F. is $4a^2 - 2a + 1$.

Explanation. Divide $8a^4 - 16a^3 + a - 2$ into the other expression. The remainder is $32a^3 + 4a^2 - 2a + 5$. This has now to be divided into $8a^4 - 16a^3 + a - 2$; so, in order to avoid fractions, we multiply the dividend by 4, obtaining $32a^4 - 64a^3 + 4a - 8$. Proceeding with the division we obtain quotient a, and remainder $-68a^3 + 2a^2 - a - 8$. Now divide this remainder into the divisor we have just been using—*viz.*, $32a^3 + 4a^2 - 2a + 5$. In order to do this, the latter ~~expressien~~ must be multiplied by 17. [To obtain the 17, take the L.C.M. of the coefficients of a^3, 68, and 32. This is $4 \times 17 \times 8$; hence 17 times 32 will be divisible by 68.] The remainder is $84a^2 - 42a + 21$. This contains a factor 21, and since 21 is not a factor of the given expressions, we reject the 21, and proceed with $4a^2 - 2a + 1$ for our divisor. This last expression divides $-68a^3 + 2a^2 - a - 8$ without a remainder, and is therefore the H.C.F.

72. To find the H.C.F. of three expressions A, B, C, we first find the H.C.F. of A and B, and then the H.C.F. of this result and C. Clearly, we shall then have found all the factors which are common to A, B, and C.

EXAMPLES 20

Find the H.C.F. of

1. $2x^3 - 5x^2 + 7x + 5$, $4x^3 - 11x^2 + 17x + 5$.
2. $6x^3 - 7x^2 + 10x - 4$, $4x^3 - 4x^2 + 15x - 7$.
3. $a^3 + 2a^2b - b^3$, $a^4 + a^3b - 2ab^3 - 2b^4$.
4. $3a^3 - 4a^2 + 9a - 8$, $2a^3 + 5a^2 + a - 8$.
5. $8x^3 - 8x^2 - 4x - 3$, $2x^4 + 3x^3 - 3x^2 - 7x - 3$.
6. $4x^4 - 4x^3 + x^2 - 1$, $2x^3 + 5x^2 - 2x + 3$.
7. $8x^3 - 10x^2 - 16x - 3$, $6x^4 - 22x^3 + 31x^2 - 23x - 7$.
8. $2x^3 - 23x^2 + 43x - 8$, $x^4 - 5x^3 - 6x^2 + 35x - 7$.

LEAST COMMON MULTIPLE

73. The Lowest Common Multiple, or L.C.M., of two or more algebraical expressions is the expression of lowest dimensions which is exactly divisible by each of them.

74. L.C.M. of Simple Expressions. The L.C.M. of simple expressions can be written down by inspection.

Example **1**. Find the L.C.M. of x^3yz, xy^4z^2, and y^2z^3.

Here, the highest power of x which occurs in any of the expressions is x^3. Any common multiple of the expressions must, therefore, contain the factor x^3. Similarly, since y^4 is the highest power of y which occurs, any common multiple must contain the factor y^4; and since z^3 is the highest power of z which occurs, any common multiple must contain the factor z^3. Evidently, then, the common multiple of lowest

dimensions is $x^3y^4z^3$. That is, the L.C.M. is $x^3y^4z^3$.

Example 2. Find the L.C.M. of $3x^2y$, $2xz^2$, $8xyz$, and $6y^2z$.

The required L.C.M. must contain each of the numerical factors 3, 2, 8, 6. The L.C.M. of these numbers is 24. Thus 24 is the coefficient of the L.C.M. required.

Again, as in Example 1, since the highest powers of x, y, and z which occur are x^2, y^2, and z^2 respectively, their L.C.M. is $x^2y^2z^2$.

Hence the L.C.M. of the given expressions is $24x^2y^2z^2$.

Thus, to find the L.C.M. of simple expressions, we

(i.) Find the L.C.M. of the numerical coefficients. This will form the coefficient of the required L.C.M.

(ii.) Write down each letter contained in the expressions, and raise it to the highest power which occurs among the expressions.

75. L.C.M. of Multinomials whose Factors are Known. The principle is the same as for monomial expressions. Write down each *factor* that occurs, raised to the highest power which it has in any expression.

Example 1. Find the L.C.M. of

$x^2 + 2ax + a^2$, $x^2 - a^2$, and $x^2 + ax - 2a^2$.

We have

$$x^2 + 2ax + a^2 = (x + a)^2$$
$$x^2 - a^2 = (x + a)(x - a)$$
$$x^2 + ax - 2a^2 = (x - a)(x + 2a).$$

The factor $(x + a)$ occurs, raised to the *second* power; $(x - a)$ and $(x + 2a)$ each occur as the first power. Hence the L.C.M. is

$$(x + a)^2 (x - a)(x + 2a).$$

Example 2. Find the L.C.M. of

$2a^4 - 2a^3b - 4a^2b^2$, $9a^3b + 12a^2b^2 + 3ab^3$, and $12a^2b^2 - 20ab^3 - 8b^4$.

Here

$$2a^4 - 2a^3b - 4a^2b^2 = 2a^2\ (a^2 - ab - 2b^2)$$
$$= 2a^2\ (a - 2b)(a + b)$$
$$9a^3b + 12a^2b^2 + 3ab^3 = 3ab\ (3a^2 + 4ab + b^2)$$
$$= 3ab\ (3a + b)(a + b)$$
$$12a^2b^2 - 20ab^3 - 8b^4 = 4b^2\ (3a^2 - 5ab - 2b^2)$$
$$= 4b^2\ (3a + b)(a - 2b).$$

As in Article 74, the L.C.M. of the monomial factors $2a^2$, $3ab$, and $4b^2$ is $12a^2b^2$. The L.C.M. of the given expressions is therefore

$$12a^2b^2 (a - 2b)(a + b)(3a + b).$$

EXAMPLES 21

Find the L.C.M. of

1. $9abc$, $15a^2b$, $2b^2c^3$.
2. $a^2 - b^2$, $(a + b)^2$, $(a - b)^2$.
3. $x^3 + y^3$, $x^3 - y^3$, $x^4 + y^4 + x^2y^2$.
4. $4x^2 + 8x - 12$, $9x^2 - 9x - 54$, $6x^4 - 30x^2 + 24$.
5. $6x^2 + 17x + 12$, $4x^2 - 4x - 15$, $6x^2 - 7x - 20$.
6. $4x^2 - 9$, $4x^2 - 12x + 9$, $6x^2 - 13x + 6$, $6x^2 + 5x - 6$.
7. $x^2 - 5xy + 6y^2$, $x^2 - 4xy + 3y^2$, $x^2 - 3xy + 2y^2$.
8. $x^2 - 4y^2$, $2xy - 6y^2$, $4xy^3 - 2x^2y^2$.
9. $a^3 + a^2b$, $2a^2 - 2b^2$, $a^2b^2 - ab^3$, $4a^3b$.
10. $2x^2 + 3x - 2$, $(5x - 7)^2 - (x - 5)^2$, $2x^3 - x^2 - 8x + 4$.

76. When the factors of the expressions whose L.C.M. is required cannot be seen by inspection, we use the H.C.F. rule.

Let A and B stand for two algebraical expressions whose highest common factor is H, and whose lowest common multiple is L.

Divide A and B by H, and let the quotients be a and b respectively. Then

$$A = a \times H,$$

and

$$B = b \times H.$$

Now, since H is the highest common factor of A and B, it follows that a and b can have no common factors. Therefore the L.C.M. of A and B is $H \times a \times b$; that is

$$L = H \times a \times b.$$

But $H \times a = A$, therefore

$$L = A \times b.$$

Hence, *the L.C.M. of two algebraical expressions is obtained by dividing one of the expressions by their H.C.F., and multiplying the quotient by the other expression.*

77. Another important result is obtained from the relation

$$L = H \times a \times b.$$

Multiplying both sides by H, we have

$$L \times H = H \times a \times H \times b.$$

But $H \times a = A$, and $H \times b = B$. Hence

$$L \times H = A \times B;$$

or, *the product of any two expressions is equal to the product of their H.C.F. and their L.C.M.*

78. To find the L.C.M. of more than two expressions, whose factors cannot be readily seen, we find the L.C.M. of any two of the expressions, then the L.C.M. of this result and a third expression, and so on until we have used every expression.

EXAMPLES 22

Find the L.C.M of

1. $2x^3 - 11x^2 + 20x - 21$ and $4x^3 - 4x^2 - 41x + 21$.
2. $a^3 - 6a^2 + 11a - 6$ and $a^3 - 10a^2 + 29a - 20$.
3. $8x^3 - 18x^2 + 13x - 3$ and $6x^3 - 13x^2 + 9x - 2$.
4. $2x^3 - 5x^2y + 4xy^2 - y^3$, $2xy^2 + x^2y - y^3 - 2x^3$, and $2x^3 + 3x^2y - y^3$.

Answers to Algebra

EXAMPLES 11

1. $x(x^2 + 6)$.
2. $a(a + b + c)$.
3. $11abc(ab - 3c^2)$.
4. $x(3x^3 - 2xy^2 + y^3)$.
5. $5y^3(y - 4x)$.
6. $3yz(13xy + 15z)$.
7. $2a(3x^3 + 2ax - 4a^2)$.
8. $17(4 - 3x^2)$.
9. $19abc^2(6a^3 + 5b)$.

EXAMPLES 12

1. $(x + a)(x + b)$.
2. $(a + 1)(b^2 + 1)$.
3. $(x - y)(ax - by)$.
4. $(a + b)(c - d)$.
5. $(x^2 + 2)(y^2 - 2)$.
6. $(x + 2y)(a - b)$.
7. $(x^2 + 1)(x - a)$.
8. $(a + bc)(x - yz)$.
9. $(x^2 + 2y^2)(x^2 + 2z^2)$.
10. $(x^3 + 2a)(y^3 - 3a)$.

Examples 13

1. $(x+2)^2$.
2. $(y-3)^2$.
3. $(5a-2b)^2$.
4. $-3(a^2+1)^2$.
5. $4(x^2+y)^2$.
6. $2a^2(x+b)^2$.
7. $(x+y+z)^2$.
8. $(a+b-\frac{1}{2}c)^2$.

Examples 14

1. $(x+1)(x+2)$.
2. $(y-3)(y-5)$.
3. $(x+4)(x-7)$.
4. $(a+17)(a-3)$.
5. $(y+15)(y-16)$.
6. $(x+5)(x-30)$.
7. $(y+1)(y+50)$.
8. $(a-3b)(a-14b)$.
9. $(x+13y)(x-14y)$.
10. $(x-11y)(x-16y)$.
11. $2(x+15y)(x-3y)$.
12. $3(a+12b)(a-14b)$.

Examples 15

1. $(2x-1)(x-2)$.
2. $(2x+3)(3x+5)$.
3. $(3x+y)(7x-4y)$.
4. $(13x-2y)(2x+7y)$.
5. $(12x+1)(11x-2)$.
6. $(9x-2)(x+16)$.
7. $(17x-3y)(x-5y)$.
8. $4x(x-2)(3x-1)$.
9. $2xy(11x-3y)(5x+4y)$.
10. $2(4x-1)(x-4)$.

Examples 16

1. $(x+11)(x-11)$.
2. $(a+4b)(a-4b)$.
3. $(1+5y)(1-5y)$.
4. $(ab+7)(ab-7)$.
5. $(6+xy)(6-xy)$.
6. $2(4x+3y)(4x-3y)$.
7. $(2x+5y+x-3y)(2x+5y-x+3y)$
 $=(3x+2y)(x+8y)$.
8. $(a+2b+a-2b)(a+2b-a+2b)$
 $=2a\,.\,4b=8ab$.
9. $(3a+3b+a-b)(3a+3b-a+b)$
 $=(4a+2b)(2a+4b)$
 $=4(2a+b)(a+2b)$.
10. $(a^2+5)^2-16a^2$
 $=(a^2+4a+5)(a^2-4a+5)$.
11. $(x^2-2y^2)^2-36x^2y^2$
 $=(x^2+6xy-2y^2)(x^2-6xy-2y^2)$.
12. $(y^2-1)^2-4y^2$
 $=(y^2+2y-1)(y^2-2y-1)$.

Examples 17

1. $(a+5b)(a^2-5ab+25b^2)$.
2. $(3a-4b)(9a^2+12ab+16b^2)$.
3. $(x^2-2y^2)(x^4+2x^2y^2+4y^4)$.
4. $2x^2(x+2y)(x^2-2xy+4y^2)$.
5. $(a+2b-a)(a^2+4ab+4b^2+a^2+2ab+a^2)$
 $=2b(3a^2+6ab+4b^2)$.
6. $\left(2a-\frac{4}{b}\right)\left(4a^2+\frac{8a}{b}+\frac{16}{b^2}\right)$.
7. $(a-2b-b+2a)(a^2-4ab+4b^2+5ab-2a^2-2b^2+b^2-4ab+4a^2)$
 $=(3a-3b)(3a^2-3ab+3b^2)$
 $=9(a-b)(a^2-ab+b^2)$.
8. $\left(\frac{x}{7}-\frac{3}{x}\right)\left(\frac{x^2}{49}+\frac{3}{7}+\frac{9}{x^2}\right)$.
9. $\left(\frac{ab}{10}+5\right)\left(\frac{a^2b^2}{100}-\frac{ab}{2}+25\right)$.

Examples 18

1. $(x^2+2x)^2-11(x^2+2x)+24$
 $=(x^2+2x-3)(x^2+2x-8)$
 $=(x-1)(x+3)(x-2)(x+4)$.

2. $(x+1)(x+2)(x+3)(x+4)-48$
 $=(x^2+5x+4)(x^2+5x+6)-48$
 $=(x^2+5x)^2+10(x^2+5x)-24$
 $=(x^2+5x-2)(x^2+5x+12)$.

3. $(x+2)(x+4)(x+5)(x+7)+8$
 $=(x^2+9x+14)(x^2+9x+20)+8$
 $=(x^2+9x)^2+34(x^2+9x)+288$
 $=(x^2+9x+18)(x^2+9x+16)$
 $=(x+3)(x+6)(x^2+9x+16)$.

4. $x^3(y-z)+y^3(z-x)+z^3(x-y)$
 $=x^3(y-z)-x(y^3-z^3)+yz(y^2-z^2)$, arranging in powers of x
 $=(y-z)\{x^3-x(y^2+z^2+yz)+yz(y+z)\}$, taking out the factor $(y-z)$
 $=(y-z)\{y^2(z-x)+yz(z-x)-x(z^2-x^2)\}$, arranging in powers of y
 $=(y-z)(z-x)\{y^2+yz-x(z+x)\}$
 $=(y-z)(z-x)\{-z(x-y)-(x^2-y^2)\}$, arranging in powers of z
 $=(y-z)(z-x)(x-y)(-z-x-y)$
 $=-(y-z)(z-x)(x-y)(x+y+z)$.

5. $(b-c)^3+(c-a)^3+(a-b)^3$. The factors of this expression are easily obtained from the following. We know that $x^3+y^3+z^3-3xyz=(x+y+z)(x^2+y^2+z^2-yz-zx-xy)$. Now, if $x+y+z=0$, the product on the right of this identity must evidently be 0, *i.e*, we have $x^3+y^3+z^3-3xyz=0$. Therefore $x^3+y^3+z^3=3xyz$. This result, expressed in words, is:

When the sum of three quantities is zero, the sum of their cubes is equal to three times their product. In the given example we have three quantities, $b-c$, $c-a$, and $a-b$. The sum of these three is plainly zero. Hence it follows that the sum of their cubes is three times their product, *i.e.*, $(b-c)^3+(c-a)^3+(a-b)^3=3(b-c)(c-a)(a-b)$

6. x^3+3x^2-6x-8
 $=(x^3-8)+(3x^2-6x)$
 $=(x-2)(x^2+2x+4)+3x(x-2)$
 $=(x-2)(x^2+2x+4+3x)$
 $=(x-2)(x^2+5x+4)$
 $=(x+1)(x-2)(x+4)$.

7. x^4+4x+3. If we put $x=-1$ we get $1-4+3$, which equals 0. Hence $x-(-1)$, or $x+1$, is a factor. Thus $x^4+4x+3=x^3(x+1)-x^2(x+1)+x(x+1)+3(x+1)=(x+1)(x^3-x^2+x+3)$. Again, putting $x=-1$ in the second factor, we see that $x+1$ is still a factor; the expression being $(x+1)\{x^2(x+1)-2x(x+1)+3(x+1)\}$ or $(x+1)^2(x^2-2x+3)$.

8. $yz(y-z)+zx(z-x)+xy(x-y)$
 $=x^2(y-z)-x(y^2-z^2)+yz(y-z)$, arranging in powers of x
 $=(y-z)\{x^2-x(y+z)+yz\}$
 $=(y-z)(x-y)(x-z)$.

Examples 19

1. abc^2.
2. $2x^2yz$.
3. $7x^3y^3$.
4. $x-6$.
5. $x+4y$.
6. $2a-1$.
7. $2a+3b$.
8. $2x^2(x-2y)(3x+y)$.
9. $3x(2x-y)$.

H. J. ALLPORT

NOTE. The section on GEOMETRICAL DRAWING is now appearing in GROUP 3

FISHES IN THEIR NATURAL COLOURS

A. Beaked Chætodon B. Scarlet Holocanthus C. Banded Chilodactyle D. Eyed Blenny E. Trigger fish F Cobbler fish G. Red-finned Aplstus H. Japanese Dragonet I. Two-spotted Cheilinus J. Fire fish K. Banded Paracirrhites L. Electric Eel M. Many-banded Mullet N. Muræna O. Zebra Sole P Semicircular Chætodon

FACING PAGE 3117

The Need for Keeping Youthful in Spirit and Alert to the Movements of the Age.

THE MAN WHO NEVER GROWS OLD

YOUTH, it may be thought, judging by first appearances, should be the real age of success, though few persons succeed in it. It is the age of superabundant energy and recuperative power, large hopes and soaring ideals. It is the age of experiment, action, and adventure. All the wisdom of experience, all the store of learning, that an old man amasses seldom compensates him for the loss of youthful daring and activity. Some of the greatest of achievements were done by mere boys. At sixteen Alexander the Great showed himself a capable governor, and at twenty he had mastered Greece and was launching out on the conquest of Asia. In our own period, Krupp founded his immense business at the age of fourteen, and Mr. Joseph Chamberlain was barely four years older when he laid the foundations of his remarkable career. In our Army and Navy most of the older men have to retire when ripe with experience to make way for the promotion of young men with less knowledge but of more active temperament. For in these fields of action the spirit and dash of youth have been found often to prove victorious against the slow and cautious wisdom of men of middle age.

In many departments of commerce, art, and science the young man still shows himself to be one of the best pioneers of new methods; and his qualities are so widely recognised at the present day that there is a general inclination to trust him with the conduct of affairs requiring rapid decision and progressive development in accordance with the changing conditions of modern life. But though the qualities of youth are of high value, there is so increasing a need for specialised knowledge in every direction that the man of middle age really possesses the advantage, if he combines his experience with the vigour and versatility of the young intellect.

The man who never grows old is the master of the situation. On the one hand, he has the practical wisdom and large accumulation of knowledge that tell more and more in the growing complexity of our industrial and scientific civilisation. He has statesmanship—a gift that is rarely native in a man, and usually purchasable only by long and varied contact with men of affairs. On the other hand, he preserves sufficient of the spring of mind and resiliency of character of youth to enable him to respond quickly to any new stimulus and lift himself out of the ruts of routine.

In itself, middle age is the most enjoyable period of life. The body has ceased to grow, but it maintains its power for some years, and the decline in physical vigour is long unnoticeable in men who are not daily engaged in manual labour. In careers where the power of the intellect is employed, a man of forty can look forward to twenty or more years of good work. Indeed, in many cases a man is at his best when he is treading the level tableland of middle age. His rainbow illusions are gone, but his real hopes have acquired substance and shape, and if he has ordered his life wisely they are within his reach.

But a man must keep youthful in spirit, full of the zest of adventure, while he is gathering the knowledge and experience of life. The danger of becoming too old at forty is commonly run by men of twenty-five. It is somewhere about this period of life that a man makes himself, and determines what kind of middle age he will have. Men now seldom come of age at the legal time of life. There is too much to experiment with and learn and practise in the intricate and extensive fabric of our social life for a youth of twenty-one to arrive at his full intellectual stature. He is still but a child of larger growth, learning in the school of the world the last lessons of life, and equipping himself for the real struggle in the arena of practical affairs.

Four or five years of this schooling enable him to discern his limitations, measure his abilities, and steady his aim. Then it is that he is in peril of becoming prematurely old. For if he narrows his mind in too intense an effort to concen-

trate his working powers, he is likely to win a little immediate success at the cost of much joy and strength and fulness of life in the latter part of his career.

We live in an age of specialisation, and success often comes to a man who sticks to one thing and does it well. In other words, many of our affairs run, like our railways, on grooves, and that man wins most quickly to his end who travels down the metalled way. But even in the grooves of modern life there is enough to keep the mind of an enterprising man alert, interested, and eager for adventure.

The great thing is to keep one's mind from sinking so deep into the rut of routine that it cannot see over into the world outside. We are living in an age of inspiring adventure in science, industry, and politics. Ancient empires are falling into ruin around us, and amid the ruins some daring spirits are labouring at works of reconstruction, full of romantic possibilities and far-reaching importance. In the world of science there are movements of upheaval and ferment and deeply based reconstruction. In physics everything is in the melting-pot. In chemistry there are immense continents of new knowledge awaiting exploration. As for the study of living things, it is now seen that Darwin scarcely got over the threshold of the mysterious house of life,, and none of its important secrets has yet been revealed. Then in industry the power of the inventor is continually changing the conditions of work, and striking the public mind with wonder and amazement.

Thus, to the man who wishes never to grow old, there is ample material around him to keep his mind supple and his spirit bold and unflagging. A lively interest in the world is the best elixir of youth. For so long as a man does not feel dull he does not feel old, and there is a good deal of truth in the saying that a man is only as old as he feels. And if it is equally true that a woman is only as old as she looks, this must be because her looks strongly influence her feelings, or because her feelings strongly influence her looks.

However this may be, it is a well-known fact that the strength and freshness of a man's spirit are largely conditioned by his outlook on life. Some young pessimists, wrapped up in their gloomy selves, feel older than a cheery and hale man of seventy who keeps all the windows of his mind open on life and Nature. "A merry heart goes all the day," sang Shakespeare; "your sad tires in a mile." And certainly a cheerful, happy nature will, in one sense, keep a man young to the end of his life.

But mere cheerfulness will not preserve the elasticity of mind and the adventurous quality of spirit from which the young intellect derives its chief power. Indeed, a happy disposition in itself is likely to lead to too quiet and settled a contentment. There must be a healthy sort of restlessness to keep a man's intelligence alert and supple, and ready to respond to any new stimulus. And this active kind of receptivity is best acquired by cultivating a variety of intellectual interests. In physical old age, senile decay is brought about by a process of hardening that affects the arteries. Many a man whose body is in its prime has allowed his intellect to harden, so that it has become unresponsive to new ideas and novel suggestions. Such a condition of the mind is worse than the impairment of the body. It is usually produced by too dogmatic a way of looking at things in youth.

It is true that when a man enters on practical life he has to make up his mind about certain things. Unless he does so, he will be wanting in force of character and directness of aim. But no one should be too anxious to make up his mind about everything. Human life is so complex, and the future lines of development of human society are so dimly shadowed forth, that there is room for ample speculation and inquiry; and a man will more than gain in suppleness what he loses in strength if he keeps a large mass of his thoughts and opinions in an unformed state, and devotes some of his spare time to looking for grounds of certainty in regard to matters about which he is still in doubt.

Some of the finest intellects in the world have retained this critical waiting attitude, and evidence of fresh growth can be traced right to the end of their careers. Among thinkers, Plato is remarkable for the continual development of fresh thoughts and new points of view. He lacks the strength and consistency of a man like Herbert Spencer, who struck out in early life a far-reaching doctrine which he spent the rest of his days in applying. But Plato has his compensations. The chief of them is that he is as immortal in appeal to minds of his own type as are the high mysteries of life on which he touches with so varied an art of approach.

In poetry, the changing attitudes of Shakespeare form an enlightening contrast with the single, steady point of view of Milton. Milton shows to the full the strength of the man who makes up his mind at an early age and then spends the remainder of his life building on it. He had an extraordinary strength of character that carried him safely through a period of political glory as well as through a period of bodily and mental trouble. Nothing could break his spirit, and in the blindness and perils of his later days he did his finest work. Shakespeare, on the other hand, had much less force of character. Too many of his interests were placed outside his own soul, and in one of his sonnets he bitterly laments that he had not a colder, stronger nature. But because he had more abundant and more vivid interests in life than Milton, his work is more varied and more comprehensive; and his last play, "The Tempest," has more of the fragrance and bloom of youth upon it than has his earliest love-poem.

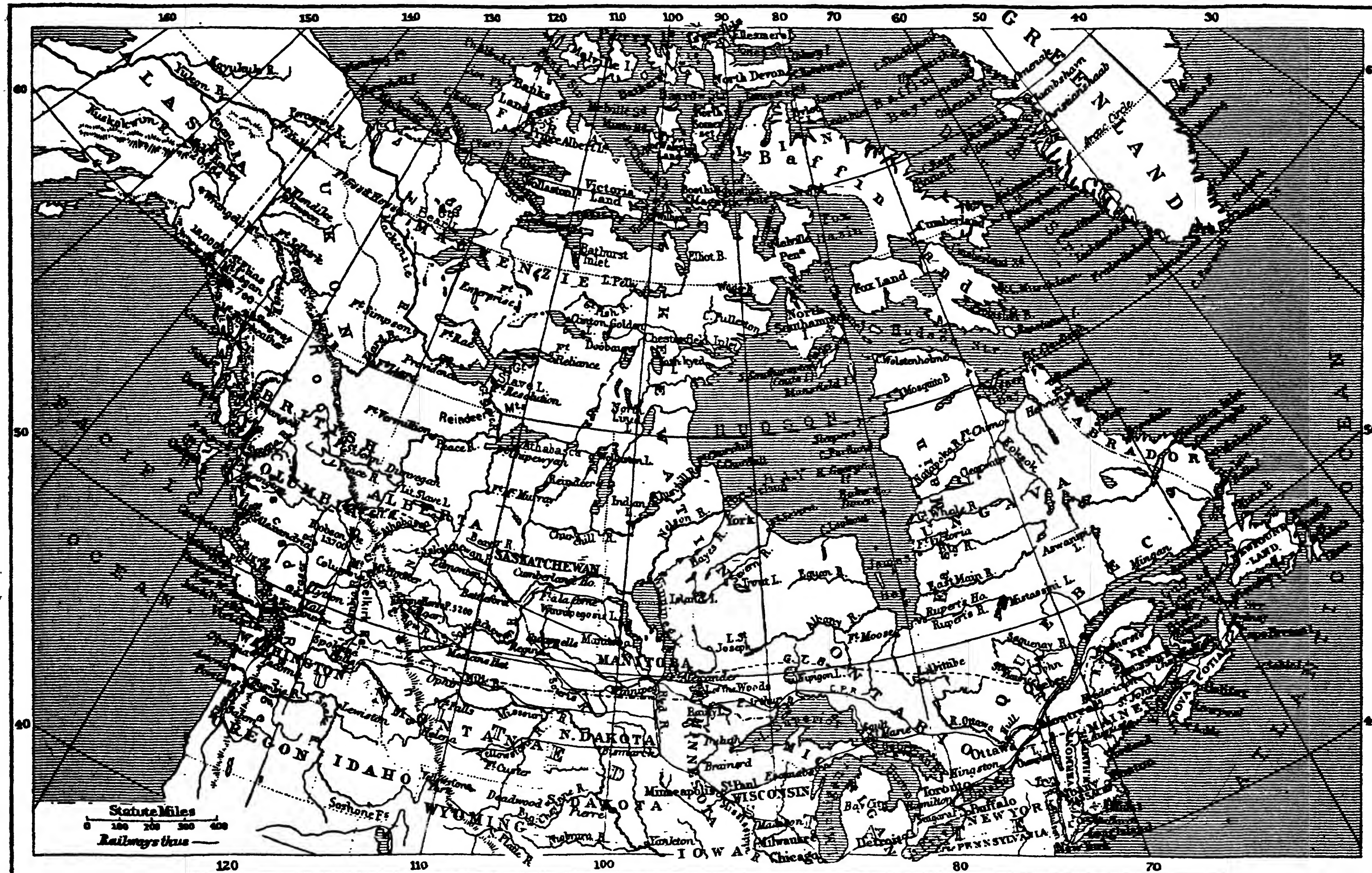
Some men of science possess this Shakespearian power of recapturing the spirit of youth after a life of hard work. The great French thinker Henri Poincaré, whom some reckon the Newton of our age, is a good example of a mind that never grew old. His openness and versatility of view pained some of his fellow-thinkers. They regarded his patient, watching, expectant attitude, and his disinclination to make up his mind on first principles, as an unseemly levity in a scientific philosopher. It was put down to a strain of French frivolity running through his massive intellect; and several well-known French dogmatists in science were hurt by the nonchalance with which he attacked the very foundations of human knowledge. But already so much has been upset in the things about which he was doubtful that his fame is greater after his death than it was during his lifetime. When his work is compared with that of English men of science who could write as well as he could—with that of Huxley and Tyndall, who made up their minds about everything early in life—the importance of retaining the youthful spirit of experiment and open-mindedness is clearly perceived.

Of course, it is difficult even for a great man in our age of speculation to keep so many interests alive in his mind as Poincaré did. But even ordinary men like ourselves must train our intellects to flexibility if we wish to retain the qualities of youth in the days of fuller experience. At the present time many men of middle age look younger than their fathers did at the same time of life. This youthful appearance is partly to be obtained by the easy method of shaving the face instead of growing a moustache and beard. But even the modern fashion of clean-shaving—due perhaps to the example of Mr. Joseph Chamberlain in the days when his alliance with the Conservative Party made him an object of admiration to clubmen—does not fully explain the unusual youthfulness of the modern middle-aged man. It is largely due to the revival of physical culture, and to the popularity of the quiet, open-air game of golf, which now lures a man out of town when football and cricket, he finds, are becoming too strenuous a form of exercise for him.

What constant physical culture does for the body a constant variety of intellectual interests will do for the mind. The only man who is too old at forty or sixty is the man who has no thoughts outside his office and his home. To keep young in mind a man must have intellectual exercise; but, unfortunately, a good many persons think that novel-reading brings all the powers of the mind into play. As a matter of fact, the ordinary modern novel is an opiate rather than a stimulant. It is only a pleasant means of passing the time away, and of erasing the business and worry of the day from the memory for a while. The modern play is usually a similar form of entertainment. Even our modern literature of revolt is often only sentimentality in a perverted form. It neither innervates the mind nor touches and stimulates the imagination.

The fact is that our literary art has become a thing of quite secondary importance. The main energies of our national life do not animate it. For good or ill, science is now the great creative force of our life; and it is chiefly by taking an interest in the development of some branch of science and by following the principal work done in it that a man can get an effective mental culture that will keep his intellect alert, open, and elastic long after he has reached middle age. And if he is connected with any industry in which the applications of scientific discoveries are of importance, he may be able to put to good use some of the knowledge he obtains.

EDWARD WRIGHT



THE DOMINION OF CANADA

The Population, Physical Features, Climate, and Resources of Canada. The Canadian Pacific Railway. Newfoundland.

THE DOMINION OF CANADA

LET us look out in a map the frontiers of Canada, noticing that its boundary with the United States is quite artificial. Of its total area (3,600,000 sq. miles) large portions are of little value. Its natural advantages include (1) vast forests, supplying timber, an asset of ever-increasing value; (2) immense and fertile wheatlands; (3) great mineral wealth, including the rich Klondike goldfields of the Rockies; (4) valuable fisheries; (5) an unrivalled series of natural waterways; (6) a healthy, bracing climate, stimulating to exertion.

British Columbia. This, the Switzerland of Canada, is the largest province of the Dominion (353,000 sq. miles). It has an equable climate, with much rain in the west. Its mountain scenery is amongst the finest in the world. The mountains provide two valuable sources of wealth—minerals and timber. There are goldmines round Rossland, in the rich Kootenay district. Thick seams of fine steam-coal occur near the Crow's Nest Pass, much of which is sent west to the Pacific ports and east to the plains. Mining towns are continually springing up in all directions. The rivers, navigable only for a short distance, teem with salmon, the canning of which is a flourishing industry. The sea fisheries off the Pacific coast, whose fiords recall those of Norway, are also valuable. The most important city on the mainland is Vancouver, whence lines of steamers sail to China, Japan, and Australia. The capital is Victoria, on Vancouver Island, near the naval station of Esquimalt. The Nanaimo coal-mines in the vicinity are extremely important. Prince Rupert is the port of the Grand Trunk Railway.

Arctic Canada. Round the Arctic Ocean and Hudson Bay lie the thinly peopled districts of Yukon (207,000 sq. miles) and North-West Territory (1¼ million sq. miles), and Ungava, the northern part of Quebec. The surface is tundra, or thin forest country, the home of many fur-bearing animals. Along the coast live a few Eskimos, but the bulk of the inhabitants are Indian hunters. A few white men are found at the trading posts scattered along the margin of the hunting-grounds. Winter lasts several months, and then all travel is performed by dog-teams or on snow-shoes. In summer, light bark canoes are used on the numerous rivers and lakes. There are no towns.

Alberta and Saskatchewan (253,000 and 243,000 sq. miles respectively). In these states the surface is prairie land, though parts are wooded. In Saskatchewan are fertile wheatlands, the area of which is rapidly growing. Owing to irrigation and dry farming, wheat is important in Alberta, which has many cattle ranches. Warm chinook winds descend from the Rockies and melt the snow, so that stock can forage for themselves most of the winter. These territories are rich in minerals. Coal is widely distributed in Alberta, and is mined for local consumption, helping to make up for the lack of timber. Petroleum is said to be abundant in the north. Towns are rising. Regina is the capital of Saskatchewan, and Calgary, which is now rumoured to be the centre of vast oilfields, of Alberta. Medicine Hat is in a ranching district. Saskatoon and Prince Albert are the wheat centres on the Saskatchewan. Edmonton, in North Alberta, in an extensive agricultural district, is the largest fur market in North America. Lethbridge has large coal-mines.

Manitoba (232,000 sq. miles). The lake province, in the centre of the continent, lies partly in the prairie wheat-belt and partly in the forest country, where lumbering is important. In the agricultural districts wheat is the mainstay, but dairy farming and the fattening of hogs are rapidly becoming important. The capital is Winnipeg (140,000 people), a great railway centre, with excellent facilities for water communication in all directions. In autumn the railway traffic is enormous, as the whole wheat harvest of the prairies has to be forwarded to the eastern markets. Winnipeg has an important university, and is rapidly becoming the political, social, educational, and commercial capital of the west. The other considerable towns are Brandon, a wheat market, and Portage la Prairie, with flour-mills.

Farming in the Great West. In the wheat-growing prairies ploughing begins in autumn, and goes on steadily till stopped by the frosts of November or December. In April, wheat is sown first, when the soil is still moist after the thaws. The early summer months may be spent in breaking up new fields in the virgin prairie, or in the care of dairy and other needful farm work. The hay harvest is carried in July, and if cattle are extensively kept there will be a maize harvest to get in for winter fodder for the dairy cows. In August the wheat is ripe and the harvest begins.

As soon as the grain is cut and stacked comes the threshing, and as soon as the threshing is over the farmer hauls his grain to the nearest railway station, where it is sold and stored in the elevator, ready for transport to the east over the Canadian Pacific Railway. [See "Farming in the Colonies" in AGRICULTURE.]

Ontario. Ontario (366,000 sq. miles), the richest province of Canada, lies between the great lakes and James Bay, a gulf of Hudson Bay. The northern climate is dry, bracing, and

extreme, but the neighbourhood of the great lakes makes Southern Ontario moist and rather enervating. Ontario is a region of low hills, lakes and rivers, many of which have falls. The north is densely forested, supplying valuable lumber. The Ottawa River brings down enormous quantities, to be sawn in the innumerable sawmills turned by the Chaudière Falls. The southern part is cleared, and dotted with towns and villages at short intervals.

The occupations of Ontario are numerous and varied. Lumbering in the backwoods makes saw-milling, pulping, and other methods of working up timber important. Southern Ontario is a farmer's country. It produces wheat, but not so much as Alberta. Farmers find dairy and mixed farming profitable, and cheese and butter are produced in enormous quantities. The Lake peninsula, between Huron and Erie, is a land of orchards, where every kind of fruit is grown, especially peaches and grapes. Wine is made in considerable quantities. Special fruit-trains run from this district in the season, supplying cheap fruit to the large cities of Canada and the United States. Round Lake Huron are deposits of salt and mineral oil. Nickel is abundant round Sudbury, and copper north of Lake Superior. Cobalt has important silver-mines. Other minerals, including gold and iron, are probably widely distributed, though almost unworked.

Industries. The fisheries of the great lakes employ large numbers of persons, and fish-trains with refrigerating cars distribute the fish to inland centres. Manufactures, carried on by water or electric power, are developing, and include textiles, railway plant, brewing, and distilling. Hamilton, on Lake Ontario, is a manufacturing centre.

Toronto, the provincial capital, with a university, is a handsome town, with a good harbour on Lake Ontario. The Dominion capital, Ottawa, a great lumber centre, is finely situated at the foot of the Chaudière Falls. It is connected by the Rideau Canal with Lake Ontario.

Ontario is well situated for commerce. Railways run in all directions, and there are many excellent harbours on the lakes. Canals have been cut to avoid the rapids between the lakes, the most important being the Soo, or Sault Ste. Marie, Canal, between Huron and Superior, where an industrial town is growing up. The tonnage which passes through the canals on the Canadian and United States sides of the rapids, in spite of being frozen five months every year, exceeds that of the Suez Canal, so enormous is the volume of trade carried by this magnificent system of inland waterways.

Niagara Falls. Lakes Erie and Ontario are connected by the short Niagara River, on which are the famous Niagara Falls. The river is a mile wide where it makes its great leap sheer down 160 ft. into the narrow, boiling ravine below, down which its waters surge to Ontario. There are practically two distinct falls, separated by an island. The fall on the Canadian side is the Horseshoe Fall, a little lower than the American fall. The power supplied by the falls generates electricity for lighting Toronto and Buffalo, and is also extensively used for industrial purposes.

Towns. Quebec (690,000 sq. miles) was founded by French settlers, and many of the inhabitants are French-speaking and of French descent. The province, which includes most of Labrador, is densely forested, and lumbering is a leading industry. Agriculture and fishing are also very important. Minerals are abundant, except coal. There is, however, ample water-power, and manufactures will be carried on by electric power.

The largest city is Montreal, with excellent communication by river, rail, and canal. It is built at the foot of Mont Royal, and has many fine buildings. The shores of the St. Lawrence are lined for miles with wharves, from which are shipped the wheat, timber, and dairy produce of the Dominion, and to which imports of all kinds are brought. The manufactures of Montreal are growing rapidly. Quebec, the capital, is one of the oldest cities in America. Its commanding situation on cliffs above the broad river makes it the Gibraltar of the St. Lawrence. Hull, on the Ottawa, opposite Ottawa, and Sherbrooke, near Montreal, are manufacturing towns.

New Brunswick. The maritime province of New Brunswick (28,000 sq. miles) has immense forests, which are often ravaged by disastrous fires. Much lumber is cut in winter, floated down in spring, and sawn and worked up in summer. Minerals are abundant, but hardly worked; the fisheries, however, are extremely valuable. The south and east are settled, but the towns are small. The capital is Fredericton, at the head of the tidal waters of the St. John River, at the mouth of which is St. John. This port is never closed by ice, and in winter it is a shipping port of the Canadian Pacific Railway.

Nova Scotia. Nova Scotia (21,000 sq. miles) consists of the Nova Scotia peninsula and Cape Breton Island. It has high hills and broad valleys, with many lakes and rivers. The climate resembles that of England, but is more extreme. Atlantic fogs are common. The coast islands are rocky and poor, but the western valleys of the interior are famous for their apple orchards. Much of the country is forested, and lumbering is important. Shipbuilding, a flourishing occupation before the days of iron and steel, has declined, but will develop as the coal-mines and ironworks around Sydney, on Cape Breton Island, increase their output. The fisheries are important. The capital is Halifax, with a magnificent ice-free harbour capable of holding the whole British Navy. Cape Breton Island somewhat resembles Scotland. Its inhabitants are for the most part engaged in lumbering, fishing, mining, and shipbuilding. Sydney is chief town.

Prince Edward Island. This small island (2200 sq. miles) owes much of its fertility to "mussel-mud," the decomposed remains of

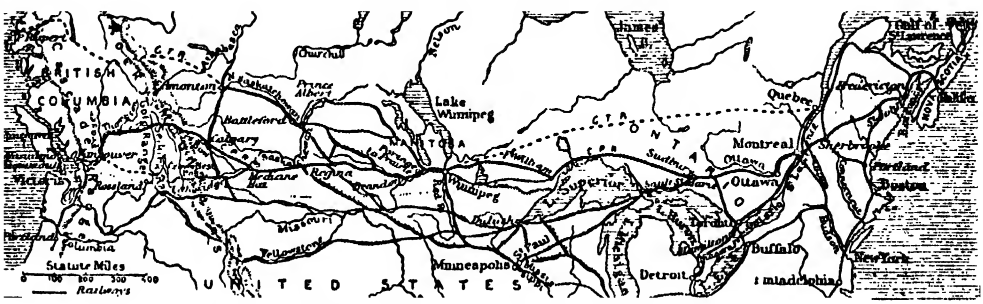
shell-fish, of which there are deposits many feet thick along the coast. The mud is raised by machinery and spread over the land, most of which is under cultivation. Dairy farming is important. Hay and potatoes are grown for the United States markets. The fisheries, especially of shell-fish, are very valuable. The capital is Charlottetown.

Newfoundland. Newfoundland (43,000 sq. miles) has been called the Norway of the New World. There is no little resemblance in the character of the island, with its long fiords running inland between high walls of rock, but the mountains are very much lower. The chief occupation in both is fishing, supplemented by some farming. The Newfoundland fisheries are among the most valuable in the world. Three parts of the catch consist of cod, taken on the shores of Newfoundland itself, on the Great Banks, a day's sail away, and off the desolate Labrador coast (120,000 sq. miles), which is included in Newfoundland. A large number of vessels go north annually to the seal fisheries.

Newfoundland is mountainous in the west, but flatter in the east. The interior is forested. Both lumbering and shipbuilding are important. Large paper-pulp works, supplying several great English journals with paper, exist at Grand Falls, belonging to the Anglo-Newfoundland Development Company. Minerals, especially copper, are abundant; iron is exported to Canada from Bell Island. Dairy farming and agriculture are developing. The capital is St. John's.

Trans-Canadian Railways. The C.P.R., or Canadian Pacific Railway, crosses Canada from ocean to ocean. The Atlantic ports are Halifax and St. John, open all the year, and the summer ports of Quebec and Montreal. The Grand Trunk line has constructed a railway from Quebec to Port Rupert, on the Pacific, north of the C.P.R., via Winnipeg, Edmonton, and the Yellowhead Pass. The Canadian Northern, from Toronto and Port Arthur, on Lake Superior, also passes through Winnipeg, Edmonton, and the Yellowhead Pass, but then turns south to Vancouver. A network of lines covers the regions round the great lakes, and connects with the lines of the United States, that by the Hudson to New York being the most important.

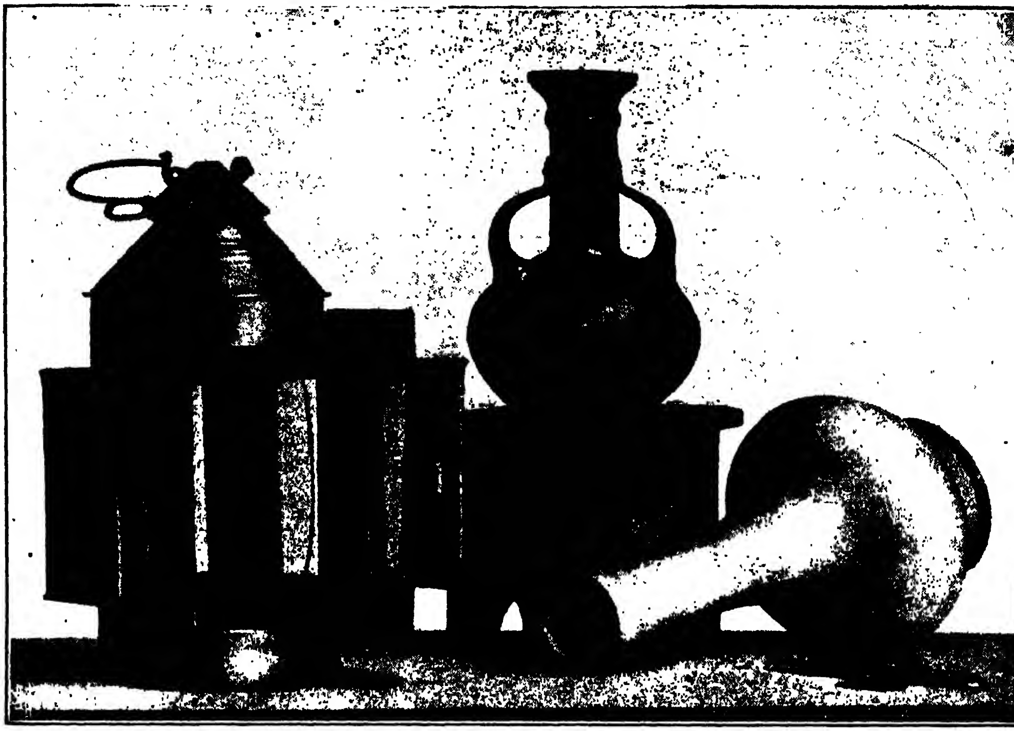
The C.P.R. The trans-continental part of the C.P.R. begins at Fort William, on Lake Superior, whence the line runs west through a thinly forested region. About 50 miles from Winnipeg the country opens out into level prairie, covered over vast areas by wheat-fields. At Winnipeg the sight of many miles of sidings and innumerable elevators brings home to the traveller the magnitude of the harvest of these vast plains. Beyond Medicine Hat the line follows the Saskatchewan valley, and reaches Alberta, in the ranching country. The distant Rockies appear on the horizon, and the line soon enters the foothills. The ascent is made by the Bow valley, amid glimpses of fine forest, mountain, and glacier scenery, to the summit of the pass (5300 ft.). The descent on the opposite side is by the precipitous Wapta valley. "The railway follows the river, crossing from side to side, and clinging to the ledges of dizzy precipices." In the first part of the descent there is a drop of 1150 feet in five miles, and in the steepest parts the speed is reduced to five miles an hour. At last the cañon opens to the broad valley of the Columbia, with a fine prospect of the Rockies on the one hand and the Selkirks on the other, with their steep forested slopes rising to the glaciers and snow-peaks beyond.



THE CANADIAN PACIFIC RAILWAY FROM HALIFAX TO VANCOUVER

A Wonderful Climb. This range is next crossed by a triumph of engineering. The line turns up the narrow gorge of the Beaver, clinging to the sides of the mountains, and turning up side valleys, till at last, between gigantic peaks, and in sight of imposing glaciers, the summit of the pass is reached (4500 ft.). The descent to the valley of the Columbia, which has gone round the Selkirks while the line has crossed them, is made by the valley of the Illicilliwaet, a descent almost as steep as that of the Wapta gorge. Here often as many as four tracks, one below the other, are in sight at once. At last, however, the Columbia valley is reached, and the line is carried across the Gold range by a low pass, which runs for many miles between vertical cliffs. Four beautiful lakes occupy the whole width of the summit level, and the line proceeds west by the Shoushwap and Kamloop lakes, to plunge at last into the gloomy Thompson cañon, from which it emerges to follow the wild cañon of the Fraser to Vancouver, the Pacific terminus.

A. J. AND F. D. HERBERTSON



396. STUMPING CHALK DRAWING OF A GROUP OF OBJECTS

397. STUMPING CHALK DRAWING FROM A CAST OF AN EARLY ENGLISH CAPITAL

Mediums. Important Principles. Lighting the Group. Keys, Divisions, and Perceptions of Light and Shade. Drawing with Chalk and Stumps.

LIGHT AND SHADE

Those students who have mastered the principles of object drawing should now attempt to shade the drawings; but it must be distinctly borne in mind that *correct* drawing, as regards proportion and perspective, must be accomplished first, for the most careful and finest shading in any medium will never hide bad drawing; rather, it will emphasise it.

Different Methods of Shading. There are many mediums in use for shading, and each has its own advantages and disadvantages. The most commonly used mediums are:

1. Powdered Chalk and Stumps. The great advantages of this medium are that errors may be easily rectified, and work may be left off at any moment. The disadvantage is that it is a medium rarely used outside a school of art, and when doing more advanced work, such as drawing from life. Yet, on the whole, it is a very convenient medium in which to work and obtain a good training in the principles of the light and shade of any object, and excellent results are certainly obtained thereby. Figs. **396** and **397** are taken from drawings made entirely with the stumps and chalk. The originals were much larger than the illustrations here given, being executed on paper 30 in. by 20 in. in size.

2. Washes of Water Colour (*sepia or liquid Indian ink*). This is undoubtedly a very good medium to use, but, as errors are not very easily rectified, most careful observation of the object, as regards its tone values and so forth, must be made in order to have in the brain a definite idea of what is wanted before making a wash on the drawing-paper This is really a very good training for a beginner, as he is compelled to observe in a most searching manner before doing a stroke of his drawing or painting, unless he wishes to get a result which has no freshness or life in it, but is all blotches, smudges, ragged and woolly edges, with the good drawing practically spoilt or lost altogether.

3. Lead Pencil. Although this is a very convenient medium, and work may be left off at any moment, yet errors are not so easily rectified as when using stumping chalk, for the pencil lines are apt to be smeared, and thus leave a greasy appearance, when rubbed with the indiarubber. There is also the objection of "shine." Most beginners have not that light and *certain* touch which is required to obtain satisfactory results with the pencil. Yet a few lines of shading properly put in quickly give the appearance of roundness or solidity to an outline drawing.

4. Academy Chalk. This has not the objection of "shine," but, like the lead pencil, requires a delicate and certain touch to obtain really good results. It is a very good medium for those students who know exactly what value of tone is wanted before they put it down on paper, which, of course, means the student must have had a good training in judging tone values before he can use academy chalk successfully.

5. Charcoal. This is a medium very much used in drawing from the antique or from the living model, and often by beginners in shading from simple objects or from a cast of an ornament. Errors may be very easily corrected, as the charcoal rubs off more easily than any other medium; but when the drawing is completed it may be "fixed" by spraying on it some shellac or gum arabic dissolved in spirits of wine. Charcoal is sometimes used with white chalk for drawing on coloured paper; brown paper will do admirably, its colour being utilised for the half-tones, the charcoal for the shadows and shades, and the white chalk for the high lights and lighter tones of the drawing.

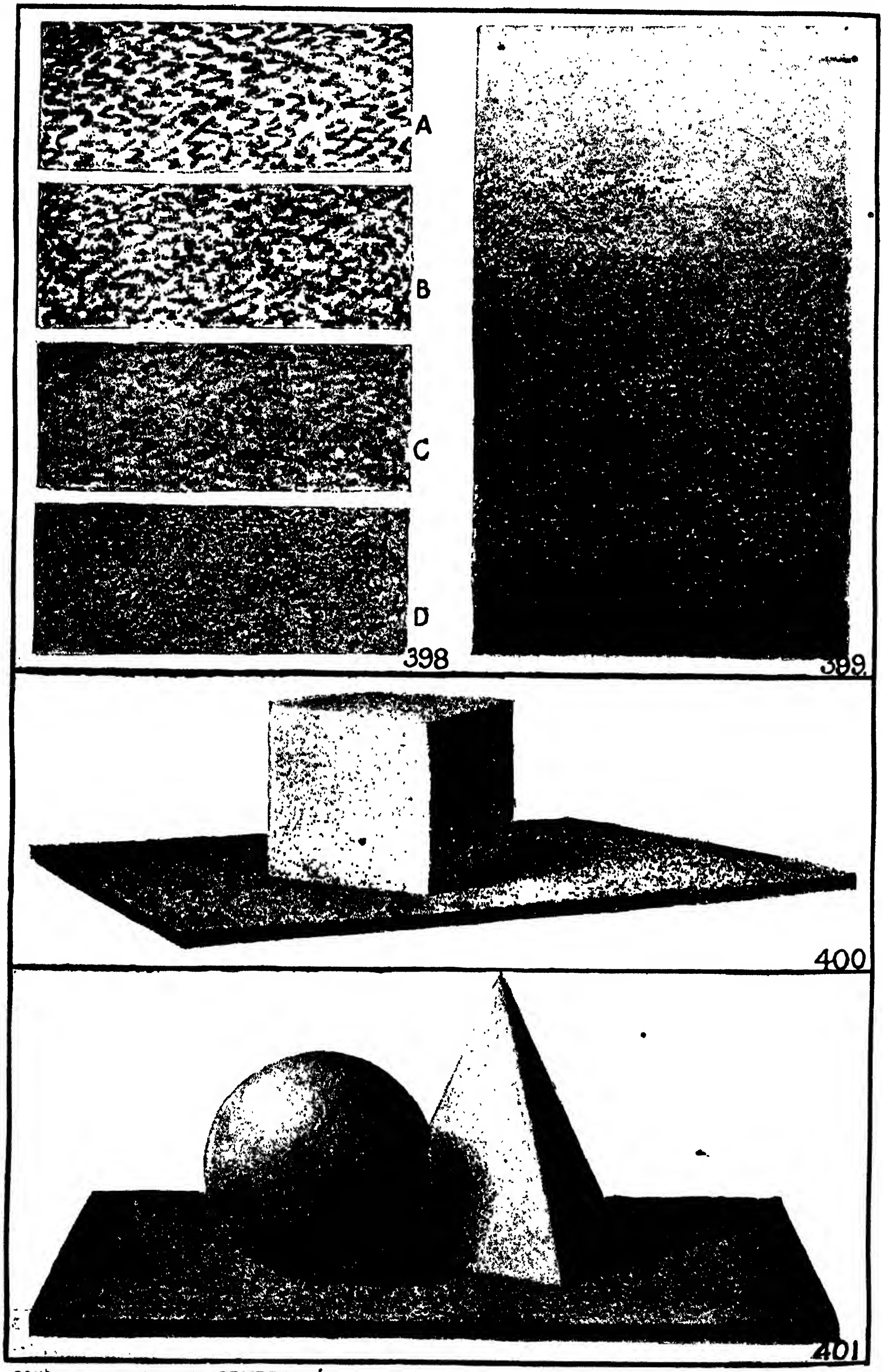
6. Pen-and-Ink. This medium is for advanced students, as considerable knowledge in drawing and shading is required before pen-and-ink work can be satisfactorily accomplished.

Principles of Light and Shade. The student must remember that he is now to represent objects, not by outline alone, but by means of light and shade; and that, although he makes a preliminary sketch in pencil, *the outline must not appear in the finished shaded drawing*, as there are no *outlines* in Nature, only edges, which are sometimes visible as light against dark, or vice versâ. Often the edges are lost in shade, or it may be that two adjoining surfaces are exactly the same tone, and so the edge is invisible. Beginners often make great mistakes about edges, because, knowing they are really there in the objects, they feel that they must be put in; but students must remember the rule: "Draw what you see." It will be found that a better sense of atmosphere and relief will be shown if the edges are lost, softened, or sharpened in their proper places.

Tones Impossible to Represent. There are so many various values of lights and darks in the objects around us that at first the student may be bewildered, and not know what to do. Sometimes the contrast between the "highest," or brightest light, and the "lowest," or darkest dark tone, is so great that, although we may be able with black chalk to obtain a tone as dark as the darkest shadow, it is impossible to represent the brilliant light with the means at our disposal, for neither white paper nor white paint is bright enough. For example, it is impossible to represent accurately some brilliant artificial light, and artists often overcome this difficulty by placing a small screen or shade in front of the brilliant light; then, although a good deal of light is seen around the screen, yet the *value in tone* of the visible light is not so bright compared with the darker tones, and can be more truthfully represented.

Lighting the Group. The preceding is, of course, an extreme example, and in ordinary cases we do not get such marked difference between "high" light and darkest shadow. The student should take considerable pains in arranging for the "lighting" of the object or objects he is studying. The light should come, preferably, from the left-hand side of the student, so that it slants down at an angle of about 45 degrees; care must also be taken to obtain a harmonious balance of light and shade. With artificial light it is difficult to avoid

METHOD OF SHADING WITH STUMPS & CHALK



 398-401 SIMPLE GROUPS FOR EXERCISES IN SHADING

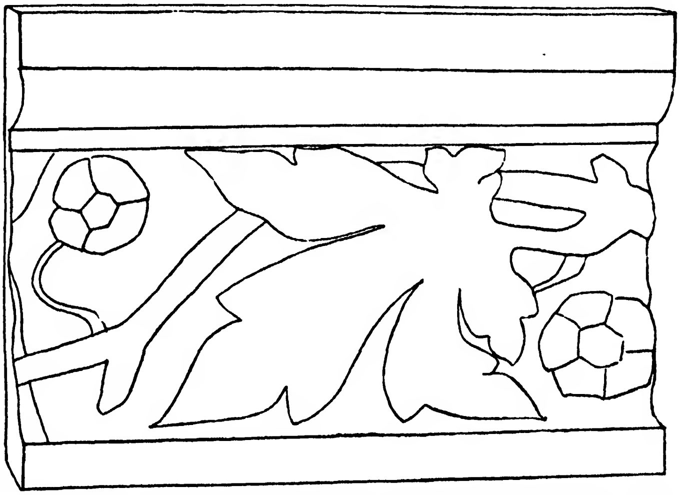
hard, sharp-edged shadows, which rarely, if ever, have an artistic effect; but if a shade of "frosted" glass be placed over the light, a more diffused illumination will be obtained, and will cause the edges of the shadows to be softer. If the objects are lighted by daylight, avoid letting the direct rays of the sun shine on the group, for the light and shade would change every minute, as the sun appears to move, and, also, the shadows would be sharp and hard. The best light is diffused daylight.

Different "Keys" of Light and Shade. A drawing may be made in any "key" of light and shade. For example, a silver-point drawing is in a much lighter or higher key of tone than a study executed in Conté crayon, charcoal, sepia, or stumping chalk, which may be in a medium or even a very dark or "low" key of tone, and yet there is an excellent representation of roundness or relief in the silver-point drawing, as in the others. Nevertheless, a beginner should not trouble about such transpositions of the key of tone, but should endeavour to represent as truthfully and accurately as he can the apparent values of the light and shade of the objects of study in *the same key as they appear.*

Divisions of Light and Shade. Light and shade may be divided into five main division, as follow: (1) *Light,* the part of the object upon which the light directly falls; (2) *shade,* the part of the object, turned away from the light, and therefore more or less dark in tone; (3) *shadow,* which is the dark portion of surrounding surfaces, and is produced by the object intervening between the source of light and the surfaces, forming a "*cast shadow,*" as it is called; (4) *half-tone,* the part of the object's surface which is between the "light" and "shade" portions; (5) *reflected light,* which is in some part of the "shade" surface, and is caused by the reflection of light from some other portion of the same or another object. Each of the above five divisions may be subdivided into very many various degrees of light, shade, shadow, and so on, for, although one part may be light, it will rarely be of the same degree of light throughout that light part; and so with the "shade," "shadow," "half-tone," or "reflected light" parts, there will usually be varying degrees of each.

Training the Eye to See Light and Shade. The student will therefore see that he has to make much careful observation and comparison before he will *see* the correct appearance of the values of the different tones. It is best to determine first the darkest "dark" and the highest or lightest "light," then it will be easier to judge all other values between these two extremes. The student's work will now be more interesting than when drawing in simple outline; he will have further means by which he can give a truer and more lifelike representation of objects or views around him; and his perceptive faculties will be put to still further severe tests of their powers of judging accurately. There must be continual and intelligent comparison between one part and *the whole,* to find out the relative values of tones, edges, and the like. It is a capital plan to place the drawing beside the objects of study, then to sit in the same place from which they are being viewed and drawn, and make careful, searching comparison between the drawing and the group. The student will be surprised how easily he will detect errors in judgment of tone values, and so on, and perhaps he will ask himself why he could not see these mistakes, or why he made them at all when working on the drawing in its usual place on the easel. The reason generally is that he has looked at each part too individually, and when the drawing is at a distance he is compelled to look at it *as a whole.* Thus, if he has an observant and critical eye, he cannot fail to see discrepancies in his work.

Yet, however critical he may be, there are sure to be errors which he cannot find by himself, owing to his lack of training, and therefore he should obtain, as often as possible, the criticism of some artist friend who has had considerable experience.



402. STAGE I. OUTLINE SKETCH FOR SHADING WITH STUMPING CHALK

Shading with Chalk and Stumps. A box of shading materials, containing all that is necessary, may be obtained of any artists' colourman. Some chalk is spread on the chamois-leather palette, or on a piece of paper, being rubbed on lightly, so that no loose particles are about; and the stump is rolled around in the chalk on the palette, so that about half or three-quarters of an inch of the pointed end is evenly charged with the chalk. Three stumps should be used—one for the darkest tones, one for the medium, and another, with scarcely any chalk on it, for the lightest tones. Always use the largest stump possible for convenience, so as to avoid a niggling style of work. *Do not rub hard,* or the work will appear dull and leaden, with no life or sparkle in it, as the pores of the drawing-paper (which should be Whatman's or O. W. S., *not* surface) should not be choked with chalk; but even in the darkest shadows there should be an appearance of little points of light showing through the dark chalk. Many students rub hard because, they say, they cannot make the tone dark enough without doing so, forgetting that it really is because they have

not sufficient chalk on the stump, which should be freshly charged very often when a dark tone is required. A piece of sharp-pointed rubber should be used to pick out the too dark spots or blotches, which will almost inevitably come where they are not wanted. Again, do not grip the stump as if it

403. STAGE II. EVEN TONE OF SHADING WITH STUMPING CHALK

were a broomstick or a crowbar, but hold it lightly, yet firmly, between finger and thumb, so that the angle it makes with the drawing-paper may be varied as occasion requires. The *side* of the stump should be used chiefly, and the point only when working in corners or confined spaces, or for certain kinds of sharp edges.

There are several methods of putting the chalk on the drawing-paper, but perhaps the best is that shown in **398**, A, B, C, and D, where in A each wavy stroke is placed close to the others in such a way that there is a general evenness of tone, although each stroke shows up rather distinctly, and the work is somewhat coarse and open. The light places should then be gone over with the stump properly charged with chalk, so as to obtain the appearance in **398**B. Then, with further use of the stump to fill in lighter places, and, if necessary, the rubber to pick out the dark blotches, produce a more even tone, as in **398**C. Last of all, finish with stump and rubber to obtain a tone like **398**D. Beginners should draw a square, about 3 in. square, and endeavour to make an even tone (like **398**D) to fill it, in order to get accustomed to the use of the stump. When this is satisfactorily accomplished, draw an oblong, about 6 by 3 in., and fill it with a graduated tone, as in **399**. Begin with the lightest tone at the top, and gradually increase the depth or darkness of the tone. There should be no sudden change from one tone to the next in this exercise, and no blotches, but an effect like **399**.

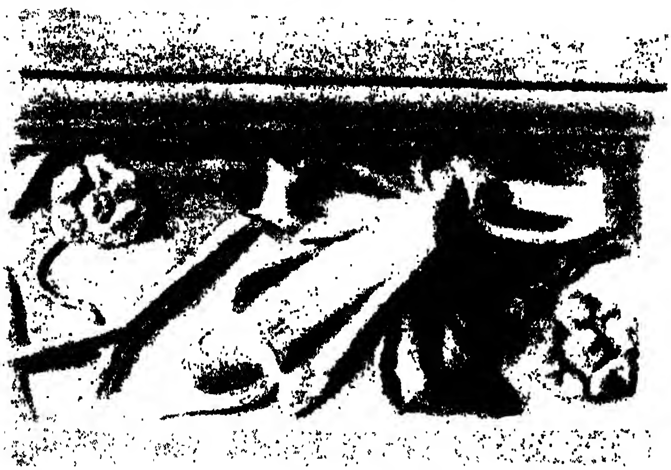
Simple Groups. Having mastered the technical difficulties of using the chalk, stumps, and rubber for obtaining an even as well as a graduated tone, proceed to study some simple group, as shown in **400**. The objects should be white or very light in colour, so that the student is not worried yet with colour values. Arrange the lighting of the group carefully, and place a large piece of white paper or cardboard vertically and about a foot behind the group, as, for the present, it is best to work without putting in the background; thus the white paper behind will help when judging the tone values of the objects in the group. Make a sketch, lightly drawn in lead pencil, not only of the objects, but also of the shapes of the shadows, and nearly rub out the pencil lines. Spend some four or five minutes in careful observation of the group—as regards its darkest and lightest tones, the different values of light and shade in the same or other surfaces, the changing value of the edge of the cast shadow, which is sharp where it is close to the edge of the object which produces the shadow, and gradually becomes softer the farther the shadow's edge is from that part of the object which causes the shadow. There may be reflected light in some shade surfaces, as in one face of the cube, and it must be particularly noticed that, although a plane surface may be equally lighted from diffused daylight or any other light, the whole surface of the plane will not necessarily appear to be of the same value of tone,

404. STAGE III. CHIEF LIGHT SHADES TAKEN OUT WITH INDIARUBBER

but may seem lighter in one part than in another, as in the drawing-board and the three surfaces of the cube.

Shading. Now proceed to shade the darkest surface and cast shadow of the cube. Dark tones should generally be put in first, as their true value

is more easily judged than that of light ones. Next put in the medium, and afterwards the lighter tones, noting all the time their relative values and darkest tones. Pay attention to the value of edges, both of the objects and of the cast shadows. Then place the drawing beside the group, and make a searching criticism, correct all errors, and put more "finish" in the texture of the shading, although "finish," as regards stippling, is not to take the place of, nor is it so important as, the *true values* of tones, edges, and so forth. Nevertheless, a certain amount of "finish" is required to represent satisfactorily the smooth texture of some kinds of materials. Do not forget that *drawing* must enter into every part of shading, for the former is not finished when the sketch in pencil is made.



405. STAGE IV. MAIN SHADOWS AND SHADES ADDED TO CHIEF LIGHTS

A more difficult group, as shown in 401, may now be attempted. Here "rounded" or curved surfaces are to be represented, but, keeping in mind the previous advice about observation of tone values, etc., no great difficulty should be found. Do not make the reflected light too bright on the lower right-hand edge of the sphere. Reflected light cannot be as bright as direct light, but is generally much darker in tone.

More Difficult Exercises. A series of exercises graduated in difficulty should be gone through, until the student is able to execute a shading of a cast as difficult as that in 397, or of a group of objects like that in 396. The intermediate groups might consist of casts of fruit, foliage, or conventional ornament, or, for example, of two bricks and a hammer or trowel, a cup and saucer, a glazed teapot, a coconut and a wooden mallet, a candlestick and a box of matches, a piece of drapery hanging in graceful folds. Make all drawings fairly fill paper not less than 22 by 15 inches.

Another Method of Shading with Stumps and Chalk. Figures 402-406 show the different stages of a more rapid method of stumping chalk shading. In 402 it will be seen that details of drawing are omitted, because they can just as easily be drawn with the stump when shading. The outline must not be too faint nor too lightly drawn, or it will be lost altogether when the next stage is done. The even tone as shown in 403 is put on with either a very large stump, or, better still, with a pad made of a piece of chamois leather tied round some cotton-wool, so that it is like a ball rather larger than a walnut. Rub the pad in some chalk, and then on an odd piece of paper, until the correct evenness and value of tone can be made. Rub the pad all over the drawing and a little outside it, so that an evenness of tone (not too dark) is obtained, and the extra tone outside may be rubbed out with the india-rubber, leaving the outside edges of the drawing fairly sharp. In the third stage pick out all the chief light tones with the pointed rubber, as shown in 404, being careful to draw the correct shape of each light, with its varying degree of intensity and different value of edge, now sharp, now soft. Fig. 405 shows the main shadows and shades put in with the stump in a broad and simple manner. Leave out all details at this stage; endeavour to represent the chief planes of the surfaces with their varying tones, and draw them of some definite shape, perhaps triangular in one place, rectangular in another.

406. STAGE V. FINISHED DRAWING WITH STUMPING CHALK

Finally, finish stage V. as shown in 406; give attention to the necessary details and values of edges; blend one tone with another, if required, and give much care to the modelling of the lightest tones.

WILLIAM R. COPE

The Dietetic Value of Meat, Fish, Eggs, Vegetables, and Fruit. Cooking Meat and Vegetables.

THE NUTRITIVE VALUE OF FOODS

We must now consider meat, the food that appears to most Western peoples as the most important of all foods. It is certainly an important form of food. It consists of very much the same constituents as the living tissues of our own bodies, and it includes all that is needed for energy. Its protein is probably, after milk protein, the most important tissue-building food that we know. Halliburton's "Physiology" gives the following table showing the average composition of various meats.

Constituents	Ox	Calf	Pig	Horse	Fowl	Pike
Water	76·7	75·6	72·6	74·3	70·8	79·3
Solids	23·3	24·4	27·4	25·7	29·2	20·7
Proteins, including gelatin	20·0	19·4	19·9	21·6	22·7	18·3
Fat	1·5	2·9	6·2	2·5	4·1	0·7
Carbohydrate	0·6	0·8	0·6	0·6	1·3	0·9
Salts	1·2	1·3	1·1	1·0	1·1	0·8

It will be noticed that about 75 per cent. of meat consists of water, and that carbohydrate is almost lacking. Again our dietetic instincts have taught us aright, for we usually take bread and potatoes with our meat, and thus make up the deficiency.

Extractives of Meat. Extractives are not separately mentioned in the above table, but butcher meat, as a rule, contains about 1·9 per cent. of extractives. The value of these extractives we have already noted—they give tastiness to the meat, and, whether in meat, meat juice, gravy, or soup, they constitute a very powerful chemical stimulant of gastric juice, and thus render meat particularly grateful to the digestion. It is chiefly the extractives of meat that render meat protein more desirable than vegetable protein.

Meat Power. If a man wish to get from meat alone all the protein necessary for tissue-building purposes, he will require to eat at least half a pound of meat, probably more than a pound of meat, a day; and if he wish to get also from the meat all his work-energy, he will require to eat about four or five pounds of meat a day.

Digestibility of Meats. Meat, well cooked and tender, unless taken in excessive quantities, is well absorbed and leaves little residue, and there is little difference in the digestibility of different meats. Mutton, however, is rather more digestible than beef; and both mutton and beef are rather more digestible than lamb and veal, but the difference is due chiefly to denser texture and to comparative lack of extractives. If all three meats be well cooked and thoroughly masticated the difference in their digestibility will be found to be very slight. Pork, on account of the fat which surrounds its fibres, takes longer to digest, and gives trouble to weaker digestions. The white flesh of fowl is usually thought particularly easy to digest, but it is questionable whether it is easier to digest than beef or mutton, except by the fact that it is tender and comparatively free from fat. The flesh of game-birds has often appetising flavours that assist digestion.

Advantages of Cooking Meat. Raw meat is very tough. Its fibres are bound together by the stringy substance known as connective tissue, and, uncooked, it requires very good teeth to tear and masticate it. Raw meat with the blood still visible in it, and looking just like the flesh it is, is repulsive to the ordinary civilised and refined man. Now, cooking converts the connective tissue into a soft, digestible substance of the nature of gelatine, and the fibres are loosened and fall apart so as to become more accessible to the digestive juices. And cooking also removes the bloody appearance of the meat and renders it more agreeable to look upon. It further makes the meat more tasty, for during cooking the opportunity is taken to add flavouring matters. In addition—though this is not an original motive of cookery—cooking kills germs and microbes, and makes the meat keep better. It certainly saves us from ptomaine poisoning and from infection with various infectious diseases, such as tuberculosis, to which animals are subject. Finally, in cold weather the warm food warms the body.

Disadvantages of Cooking Meat. In these respects, then, cooking is a wise thing, but cooking has its disadvantages. It is true that the meat is separated into its constituent fibres, and thus rendered more permeable to the digestive juices, but the cooking coagulates the protein of the meat and makes it less easily digestible, so that, appetite-juice being equal, the raw meat is more digestible than the cooked meat. It has been found by experiment that raw beef is digested in two hours, boiled beef in three hours, and roast beef in four hours. In order to get the most nutrition from meat it is best taken minced and raw, and the ugly appearance can be easily disguised in various ways, as, for instance, with cream, but it is not likely that raw meat will ever become fashionable in ordinary diet.

Various Ways of Cooking Meat. Meat may be cooked in various ways. It may be roasted, boiled, fried, or stewed. When meat is roasted it should first of all be exposed to a temperature high enough to coagulate the proteins on its surface. In this way the juices in the interior of the meat are sealed up. The meat is then roasted at a lower temperature. The outer brown layer on the surface of roasted meat has a strong flavour, and is a potent stimulus of the digestive juices. It is called *osmazone.*

Meat is boiled on the same principle. It is first plunged into boiling water so that the coagulum on the surface may form a kind of bag to retain its internal flavours and juices. It is then cooked in water at a temperature considerably below boiling-point, since it is found that meat is more tender when it is cooked at a comparatively low temperature. Fish keeps its flavour better if it is boiled in sea-water, or in water to which salt has been added.

When meat is fried the high temperature of the oil at once forms a superficial coagulum.

In the case of stewed meat there is no advantage in forming a coagulum, since any juices that escape are retained in the gravy and are consumed with the meat. Stewed meat, therefore, should never be boiled, and should never, indeed, be exposed to a higher temperature than 180° Fahr. Stewing is perhaps the best way to render meat tender, tasty, and digestible, and probably the best way to use tinned meats.

Beef-Tea and Soup. It should be understood that beef-tea is not a food. It contains merely the flavouring matters of the meat, and is an appetiser, not a nutrient fluid.

Soup made from meat and meat bones also contains the flavouring matters of meat together with gelatine. It is the gelatine in the soup that makes it solidify when cooling; and it must not be imagined, as many people do imagine, that a soup is nutritious and strengthening simply because it solidifies when cold.

Fish. Fish is often considered easy to digest, but it must be remembered that fish lacks the stimulating extractives of meat, and therefore in lack of appetite will not be readily digested. Its nutritive value varies a good deal with the fat it contains. Fat fish, like eels or salmon or herring, are much more nutritious than lean fish, like whiting or sole.

There is a popular idea that fish-flesh contains an unusual amount of phosphorus, and that therefore it is good for brain-workers. Fish does not contain any more phosphorus than meat and bread, both of which supply quite enough phosphorus for the most active nervous system; and if fish be good for brain-workers, it is good mainly because it is a light form of diet, does not tempt to excess, and puts little strain on the excretory organs.

Eggs. Next in importance as complete foods, after milk, cereals, and meat, we may place eggs. The egg contains all that is necessary to build up a bird, and practically all that is necessary to build up a man. The eggs most in use for foods are the eggs of the hen, duck, goose, and turkey, and the following table, given by Wiley in "Foods and Their Adulteration," shows their comparative chemical constitutions.

CHEMICAL CONSTITUENTS OF EGGS.

	Water per cent.	Protein per cent.	Fat	Ash per cent.
Hen	73·7	13·4	10·5	1·0
Duck	70·5	13·3	14·5	1·0
Goose ..	69·5	13·8	14·4	1·0
Turkey	73·3	13·4	11·2	1·9

It will be seen that there is not much difference in the nutritive value of these eggs, and that the chief difference is a difference in the amount of fat contents. But in any egg there is a considerable difference in the nutritive value of white and yolk. Of the two, the yolk is the richer in protein, and much the richer in fat and mineral salts. The following table compares the constituents of the two.

WHITE AND YOLK OF EGG.

	Water	Protein	Fat	Other non-nitrogenous Matter	Mineral Matter
White ..	85·7	12·6	0·25	—	0·59
Yolk ..	50 9	16·2	31·75	0·13	1·09

The proteins of egg are known as vitellin and nuclein, and the latter contains both iron and phosphorus. The fats are like the fats of cream and butter and meat, and are easily absorbed.

Egg Constituents. Since eggs contain plenty of protein and plenty of lime and iron, they are suitable food for building up the tissues of growing animals; and since they contain phosphorus, in the shape of nuclein and lecithin, they are particularly useful in building up the nerve tissues which contain phosphorus in these forms, but eggs lack carbohydrates, and therefore are not good food for those expending muscular energy. As an all-round food they should be supplemented with carbohydrate food; and man's dietetic instincts have taught him to take eggs on toast, and to put them in starchy, farinaceous puddings. Raw eggs are more easily digested than soft-boiled eggs, and soft-boiled eggs more easily digested than hard-boiled eggs.

Let us now give a glance at the dietetic value of vegetables and fruits.

The Potato. The prince of all vegetables is the potato. No other vegetable in the world, excepting, of course, some cereals which we have separately considered, is consumed so largely as potatoes. Every plate of meat, whether beef, or mutton, or lamb, or any other kind of flesh, must in England have its potatoes, and so the consumption is enormous. The constituents of an average potato are shown in the following table:

COMPOSITION OF A POTATO.

	per cent.
Protein and other nitrogenous matter	2·50
Starch	20·00
Cellulose	1·04
Sugar and gummy matter	1·09
Fatty matter	0·11
Pectates, citrates, phosphates, and silicates of lime, magnesium, potassium, and sodium ..	1·26
Water	74·00
	100·00

It will be seen that about three-quarters of a potato consists of water, that about a fifth consists of starch, that there is not much protein, and that fat is almost nil. Some floury potatoes have an even larger proportion of starch, and some waxy potatoes more protein.

The Food Value of Potatoes. A potato is essentially a starchy food, and its best place is as a supplement to meat to correct the deficiency of meat in carbohydrate, but it is possible to live on potatoes alone, as has been proved in special experiments, and the Irish peasantry used to live almost entirely on their "murphies."

To live on potatoes alone, however, one must consume about five pounds a day, and five pounds of potatoes a day is apt to produce that distension of the abdomen common among the potato-eating Irish peasantry, and known as *potato belly*.

It is very important that potatoes should be well cooked. A well-cooked, mealy potato is easily digested, but a waxy potato, insufficiently cooked, is little less digestible than a golf-ball.

Peas, Beans, Lentils. After potatoes, in order of importance, come peas, beans, and lentils. These are very exceptional vegetables, in that they contain a considerable percentage of protein. Sir Risdon Bennett, in "The Book of Health," gives the following table, showing the composition of beans, peas, and lentils:

COMPOSITION OF BEANS, PEAS, AND LENTILS

	Dried Green and Skinned Broad Beans	Haricot Beans	Dried Peas	Lentils
Nitrogenous matter	29·05	25·5	23·8	25·2
Starch	55·85	55·7	58·7	56·0
Cellulose	1·05	2·9	3·5	2·4
Fatty matter	2·00	2·8	2·6	2·6
Saline matter	3·65	3·2	2·1	2·3
Water	8·40	0·9	8·3	11·3

A glance at this table will show at once that peas, beans, and lentils are rich and concentrated protein and carbohydrate foods.

Beans—For and Against. But, as we have before suggested, we have to consider not only the quantity of nutrient material in a food, but also its digestibility; and, unfortunately, peas and beans and lentils are not very easy to digest and absorb. A gram of pea protein is not therefore by any means so valuable as a gram of milk or meat protein, and peas and beans cannot be considered adequate substitutes for chops and steaks. They contain, moreover, a good deal of sulphur, which is apt to cause flatulence, and a nitrogenous substance called "xanthin," which is believed to produce uric acid, and to be bad for the gouty. Still, they are useful as partial substitutes for meat; and owing to the large quantity of lime they contain they ought to be good for growing children, provided always the children can digest and assimilate them.

Watery Vegetables. Most other vegetables, such as turnips, and carrots, and cabbages and cauliflowers, consist mainly of water—sometimes 90 per cent.—and are valuable chiefly for their flavours and for the mineral salts they contain. In some cases they are useful to supply a residue and encourage movement of the bowels. Beetroot may be specially mentioned, because of the large content of sugar.

Cooking Vegetables. All grains and vegetables consist mainly of vegetable protein and starch grains, together with a considerable quantity of an indigestible woody substance called cellulose. Some of this cellulose surrounds the starch and protects it from the digestive juices, and the main advantage of cooking vegetable foods is that heat and moisture break up the cellulose envelopes and expose the starch to the digestive juices. The vegetable protein, like meat protein, is coagulated by heat and rendered less easily digestible, but, on the whole, cooking increases the digestibility and nutritive value of vegetables.

When vegetable sugar is cooked it may be converted into caramel or barley sugar or invert sugar, but these changes are of no dietetic importance. Fats, whether vegetable or animal, are unaffected by cooking.

Fruits. Fruits in many cases consist, like most vegetables, mainly of water, with a little protein and a little sugar, and are valuable chiefly for their flavours and their alkaline salts, which may, perhaps, have more physiological action than we know; but some fruits, such as dates, grapes, figs, raisins, have nutritive value because of the easily assimilated sugar they contain. Others, such as bananas, contain large quantities of starch, while others again, such as olives, contain large quantities of oil. A fig contains more nourishment than the same weight of bread, and a few figs or a few dates and a cupful of milk will suffice for a meal.

Nuts. The nuts must be given a special place among fruits, for they contain large quantities of protein and fat, and a considerable amount—sometimes a great amount—of carbohydrate. No food, in fact, contains so much nutriment in so small a bulk as nuts. Almonds contain 24 per cent. of protein, 54 per cent. of fat, and 10 per cent. of carbohydrate. Dried chestnuts contain 71 per cent. of carbohydrate. Dried walnuts contain 15 per cent. of protein, 62 per cent. of fat, and 7 or 8 per cent. of carbohydrate. So much protein commends nuts as tissue-building food, and so much fat commends them as suitable fuel for warmth and energy, and they are certainly good in both capacities, but their usefulness is restricted by the fact that their nutrient constituents are mixed up with a good deal of cellulose, which hampers digestion. They are so hard, too, that unless the eater have a good set of teeth to prepare them for his stomach they require to be artificially ground to give the digestion a fair chance. It is quite possible to live on nuts, and various enthusiasts do so, but it is better to be catholic than exclusive or eclectic in one's dietary; and it is very doubtful whether it is possible to attain to the same level of health and vigour on a diet of nuts alone as on a mixed diet containing nuts, and bread, and meat, and vegetables, and the other aticles that man has selected for food.

RONALD MACFIE

Weight and Constituents of Milk. Cooling, Sterilising, and Pasteurising. Composition of Cream, Separated Milk, Whey, and Buttermilk. Analysis. The Sale of Milk

MILK AND ITS PRODUCTS

ALTHOUGH a fluid, milk contains food in the form of fat (the chief constituent of butter), sugar, casein (a most important albuminoid), and various mineral matters. Its average composition is shown in the following table, which, with later tables, is from "Elements of Dairy Farming," by the author.

Constituent	Average Quality	Low Quality	High Quality
Fat	3·35	2·50	6·91
Casein and albumin.	3·45	3·04	3·48
Sugar	4·83	4·90	5·02
Mineral matter ..	·72	·66	·72
Water	87·65	88·90	83·87
	100·00	100·00	100·00

If, however, we take the estimates and average analyses of various British and foreign authorities, the average fat percentage reaches 3·7, and the solids other than fat 9 per cent. [See also the chapter dealing with milk as a food, page 2939.]

Colour. Milk varies in *colour* in accordance with the breed or individuality of the cows producing it. Jerseys and Guernseys, South Devon cows, and similar cattle in France and Denmark produce milk of richer colour than most native breeds, this colour being due to the globules of fat which are held in suspension, and which, when removed, leave the fluid white. If, however, the casein or curdy matter be also removed, as in the cheese dairy, the whey, which is the liquid remaining, is of a greenish-yellow colour, containing nothing but sugar and the mineral matter.

Solids. The solid matter in milk is held partly in suspension and partly in solution, the proportions, as estimated by Duclaux, being as follow in milk of very poor quality.

Solids	In Suspension	In Solution
	Per cent.	Per cent.
Fat	2·75	—
Sugar	—	5·38
*Casein (and albumin)	2·72	·55
Phosphate of lime	·21	·14
Soluble salts ..	—	·35

* Duclaux includes all nitrogenous matter under this term.

Milk varies in quality with the breed, the age of the cow, the time which divides each milking, the date which has elapsed since the cow calved, and the condition of her health. The first milk drawn, too, is much poorer in quality than the last milk, hence the importance of thoroughness in milking.

Colostrum. Whatever may be the quality of the milk of the individual cow, or the difference between the various cows in a herd, the composition of the milk of mixed herds is very similar, owing to the fact that the milk of each cow is mixed before it is despatched to the purchaser. The first milk yielded by a cow after she has produced her calf, and known as *colostrum*, is poor in fat, but extremely rich in casein and albumin, which is present in all milk, but usually included under the term casein.

Morning and Evening Milk Compared. As the cow, however, progresses and becomes stale—namely, as she approaches the time of drying—her yield diminishes in quantity but sensibly increases in quality. It is believed, too, that with the increase in age, especially after a cow has reached six years, her milk increases in quality, but facts do not fully warrant any statement being made as to its general application. When a cow is milked every twelve hours the milk she produces is practically identical in quality; but where the afternoon or evening milking is—as is the case in this country—from seven to nine hours after the morning milking, the quality is sensibly increased in the evening, and as sensibly diminished in the morning. The evening milk is, therefore, weight for weight, much more valuable than the morning milk.

Influence of Food. The influence of food on the quality and value of milk is not fully recognised. Producers, as a rule, believe that they can improve the fat contents by high feeding, but this is not borne out in practice, and it is distinctly opposed to scientific teaching.

Cooling and Aerating. It is important that milk should be *aerated*, and, if intended for sale, *cooled* as soon as it is drawn. The cooling of milk is imperative, for unless reduced to a temperature of about 50° F. in hot weather it will scarcely keep half a day, or sufficiently long to arrive sweet upon the breakfast or tea table. The modern system of cooling, by means of either the *horizontal* or the *lenticular cooler*, provides complete aeration by which the cow-like odour of the milk is removed. The horizontal form consists of a number of tubes which cold water enters at the bottom and passes out at the top, while the milk runs from a receptacle above over the outside of the tubes, and passes into the churn as it leaves the bottom of the cooler. It will thus be observed that when the milk is coldest it leaves the refrigerator at its coldest point, and thus with sufficiently cold water it may be reduced from a temperature of 90° F. to 50° F. in less than a minute. In the lenticular cooler, the principle adopted is similar, although ice may be packed within the interior in those made for this particular purpose. In both cases the milk passes over the cooler in the form of a thin film, and is therefore well exposed to the air, and its temperature more easily reduced. If cool milk be retailed in vessels which are covered with a white cloth it should keep sweet during the hottest weather. Where milk is placed in a vessel, and especially if it be covered with a lid, without cooling or aerating, its disagreeable odour is largely retained. The exposure of milk to any pungent smell should always be avoided, as it possesses a property of absorption which may render it almost unfit for use, or even for conversion into butter.

Specific Gravity. The density or *specific gravity* of milk varies in accordance with its quality. Specific gravity is taken for all ordinary purposes by the aid of an instrument known as the *lactometer*, but it is important that the temperature should be observed, inasmuch as milk expands with heat. A gallon of pure water weighs 10 lb. at 60° F. when the barometer stands at 30 in. Under similar conditions milk may weigh from 10·27 to 10·34 lb. per gallon, its specific gravity, by altering the decimal point, thus being 1·027 to 1·034, figures which may be regarded as the limits. Although it is quite possible that, while pure, milk may possess a density represented by either of these extremes, yet the probability is that it is watered or skimmed. Obviously the fat globules of milk are lighter than the water of milk, which, as we have seen, forms some 87·5 per cent. of its composition, but the remaining constituents—the minerals, the casein, and the sugar—are heavier. If, therefore, we remove the cream, which contains practically all the fat, the density of the milk is raised; whereas if we add cream to pure milk it is reduced. The reason why milk is slightly heavier than water is due to the fact that the sugar, casein, and mineral matter, owing to their larger quantity, influence it more than the fat. Again, if water be added to milk, its specific gravity is reduced; thus, milk with a low specific gravity is usually regarded as watered milk. If we take a pure sample and assume that its specific gravity is 1·031, the figure will be increased by the removal of the cream. If we add 10 per cent. of water, the density will be reduced to 1·029, and still further reduced point by point until, when 50 per cent. of water is added, its density stands at 1·016.

Testing for Adulteration. One of the common practices of the day is the addition of separated or skimmed milk to new or whole milk. As by the Government standard milk offered for sale must contain 3 per cent. of fat, it follows that a vendor can dilute a rich sample—one which, for example, contains 3·7 per cent. of fat—with separated milk and still remain on the right side of the law, although the practice, if known, would subject him to prosecution. If we assume that pure milk of good quality varies from 1·029 to 1·032, neither of which figures are extreme, there is reason to suspect its purity if it falls below the former or is raised higher than the latter figure. A high specific gravity—1·034, for example—suggests the addition of separated milk. It is important in testing with the lactometer to obtain a table which is frequently sold with the instrument in order that, whatever its temperature when tested, its actual specific gravity may be recognised by reference to the figures. Just as milk expands with a rising temperature, so it contracts as the temperature falls, but this contraction ceases at about 4° C., below which expansion again begins.

Fleischman has shown how the constituents of milk are divided in the process of butter and cheese making. His figures are as follow.

Substance	Water	Fat	Casein	Sugar	Ash
Whey ..	78·9	3·2	22·3	76·6	60·3
Buttermilk	14·0	2·3	13·8	11·2	12·5
Skim cheese	3·6	11·5	61·5	4·2	26·7
Butter ..	·6	81·5	·6	·2	·5
The loss ..	2·9	1·5	1·8	7·8	—
	100	100	100	100	100

It should be pointed out, however, that in the manufacture of skim cheese a larger quantity of fat is left in the skimmed milk than under other conditions.

The Fat in the Milk. If a drop of milk be placed beneath the microscope, the field will be covered with a large number of tiny globules somewhat evenly distributed, although somewhat irregular in size, especially in the milk of Channel Islands cattle. A drop of the last milk drawn from the cow at milking time will contain a much larger number of these globules than a drop of the first or *fore* milk, while the latter will contain still more globules of fat than are seen to be present in a drop of *skimmed* milk.

Fat globules of average size measure about $\frac{1}{5000}$ of an inch in diameter, but the largest globules are about $\frac{1}{5000}$, and the smallest $\frac{1}{12000}$ of an inch. The number of globules present in a cubic millimetre ($\frac{6}{1000}$ of an inch) has been estimated at from a million to $3\frac{3}{4}$ millions. The fat of milk, which is represented by these globules, chiefly consists of *olein*, *stearin*, *palmitin*, *butyrin*, *caproin*, and *caprylin*, palmitin and stearin being regarded as solid fats, and the remainder as liquid fats or oils. The constituents butyrin, caproin, and caprylin in their corresponding form of fatty acids are volatile. If we take the average size of the fat globule of the Guernsey and Jersey cow at 100, and its diameter at $\frac{1}{9000}$ of an inch, the size of the globule in other milks will be found to vary from 110 to 133, and the diameter from $\frac{1}{10000}$ to $\frac{1}{12000}$ of an inch.

Size and Number of Globules of Fat. In an investigation in which the milk of 15 cows of six different breeds was submitted to 150 examinations, it was found that the number of globules of fat produced by the average animal was about 136,000,000 per second.

The size of the globule, it may be said, exerts an important influence on the success of a butter dairy. The larger the globule, the quicker it rises to the surface where milk is set for cream; while the smaller the globule, the longer the delay, and therefore the greater the difficulty in reaching the surface—a difficulty which becomes impossible when, owing to such delay in warm weather, acidity begins, the milk is coagulated, and the passage upward blocked. The fats of which the globule is composed are in no case constant in quantity—especially varying with the temperature and probably with the food consumed. In winter the solid fats are larger in proportion, and the food smaller, while the volatile fatty acids frequently vary as winter approaches to such an extent that pure butter has, upon analysis, frequently been condemned as margarine owing to the similarity in its composition to that imitation butter in this particular respect.

Agreeable as milk fat is to the palate, its odour and flavour are rapidly changed by exposure to light and air. This change is believed to be due to the decomposition of the glycerides of the volatile fatty acids, which is retarded by the aid of salt and various chemical preservatives—which, however, should never be used. Decomposition is retarded by the skilful removal of all foreign matter in the manufacture of butter, especially of the sugar and casein, which, owing to the fact that they are present in the cream, find their way into imperfectly made butter.

The Sugar of Milk. This is one of its most constant solids, and the one which in the process of cheesemaking almost entirely remains

in the whey. It is composed of carbon and the elements of water in the following proportions.

Carbon ..	40·00
Hydrogen	6·66
Oxygen	53·34
	100·00

Sugar of milk does not ferment so easily as cane sugar. It can be obtained from milk by the evaporation of the fluid in which it is in solution after the extraction of the casein and fat. In its pure state it keeps well, and is soluble in hot water or in five to six parts of cold water.

The Casein of Milk. The albuminoid matter of milk, which includes albumin, is usually described by this term. The following figures represent the composition of casein:

Carbon	53·83
Oxygen..	22·52
Hydrogen	7·15
Nitrogen	15·65
Sulphur	A trace

Although casein can be precipitated by various acids, including the lactic acid of milk itself, which causes spontaneous coagulation or curdling, it is in the process of cheesemaking coagulated by rennet, to which reference is made in a subsequent chapter. Casein is one of the three important constituents of cheese, of which it forms about one-third. It is present in cream in small quantities, but should be entirely absent from butter, in which, as it decomposes, it causes a disagreeable flavour and odour. The albumin of milk, unlike the casein, is not precipitated by rennet, but by heat; hence the practice of many cheesemakers of *cooking* the curd, as it is termed—that is, heating it to an unusually high temperature. The albumin of milk is believed to form about one-sixth part of its albuminoid matter.

The Mineral Matter or Ash of Milk. This is utilised in the animal economy in building up the body and other structures of the body of which minerals form part. It is extracted from the soil by plants, and conveyed by them in the form of food to the cow. Average milk contains about 0·7 per cent. of mineral matter, usually described as ash, for the reason that when the solid matter of milk is burnt the minerals remain in that form. The chief mineral constituents of milk are *potash, lime, phosphoric anhydride*, which forms about one-third of its total weight, *chlorine, soda, and magnesia.* Where milk is sold the loss of fertile matter to the soil from which the cows are fed in the course of a year is considerable, owing to the removal of the nitrogen in the casein, and the potash and phosphate of lime in the ash. These three materials, as we have shown in dealing with the science of manuring [page 305], form the three cardinal constituents of the soil, and those which are essential for the growth of crops. Where, however, cows are fed upon purchased cake or corn, and especially where, in addition, artificial manures are employed, the loss through the medium of the milk may be ignored, that loss being variously placed at from 20s. to 25s. per cow per annum.

Bacteria in Milk. The maintenance of the sweetness of milk is almost as important as its purity. Milk changes with great rapidity during hot weather, and at all times acidity is induced by the presence of microscopic plants known as *bacteria.* [See BACTERIOLOGY.] The souring of milk is due to *lactic acid bacteria,* which convert the sugar of milk into lactic acid. Bacteria causing putrefaction and various diseases may also be present. Milk also contains a variety of unorganised ferments, some of which are responsible for the ripening and flavour of cheese, and of moulds. Among the former may be mentioned *galactose.*

Sterilisation. Lister has demonstrated that where sterile milk is drawn from the cow into a sterilised bottle, if contact with air be prevented, and if the bottle be hermetically sealed, the milk will keep. Milk, however, is now in daily practice sterilised by submission to heat at 212° F. for half an hour. The milk is first cleaned in the centrifugal separator, from which the cream tube is removed; as it revolves, the dirt, the bacteria and other impurities are thrown to the sides of the vessel. It is subsequently passed into bottles, placed in the steriliser, with the stoppers loose, submitted to the required heat, when the stoppers are closed by a gloved hand in the live steam, so that the entrance of fresh germs from the air is prevented. Milk prepared in this way may be delivered to customers by the dozen, or by a week's or fortnight's supply according to arrangement. Unfortunately, sterilised milk is very unpalatable.

Pasteurisation. Pasteurisation differs from sterilisation inasmuch as the milk is submitted to a lower temperature—175° F.—by which the bacteria are destroyed but not the spores. Coagulation of milk does not take place until from 7 per cent. to 8 per cent. of lactic-acid has been produced. If before this quantity be present the acid is neutralised by the addition of an alkali, coagulation is postponed, but neither alkaline nor other so-called milk preservatives should in any case be used. Although the opinions of experts differ as to the influence of these materials, the majority of medical opinions is to the effect that they are deleterious to health, and especially to children and invalids. Pasteurised milk will keep longer than raw milk.

Cream. Cream is a milk product which possesses no definite standard. It may be thin or thick when removed from the milk; its thickness depends partly upon temperature, partly upon the presence of acid, and partly upon the quality of the milk and the system of skimming or setting adopted. By the aid of the *separator*, it can be removed as thin cream—which means that it contains more of the milk serum. If set at a low temperature, and if the milk be cooled before it is set, the cream will be thin. Cream cooled on ice, or slightly heated, will become thicker. In the latter case its apparently more substantial character is owing to the presence of acid and the slight coagulation of the casein. Very rich cream may contain only one-third of its weight of water, and very thin cream two-thirds.

Devonshire Cream. Clotted cream, as made in the West of England, contains some 60 per cent. of fat and 33 per cent. of water, with approximately 5 per cent. of casein. Commercial cream is frequently preserved by the aid of chemical preservatives, for which reason it is a less desirable food. If milk be set in open vessels with a depth of 5 in. to 6 in. for 12 to 24 hours for the cream to rise, and the whole be then scalded to 170° F., there is slight coagulation—in such a case the cream becomes *clotted.* In this form it is not only highly appreciated on the table, but keeps longer. The remark applies equally to the milk serum remaining, and to the butter produced from the cream itself.

The Separator. If cream of 10 per cent. quality be removed by separation, that quality should be high. At wholesale price, 100 lb. of milk, or 10 gallons, would cost during the six months April to October, 6s. 3d.; so that one gallon of

cream costs 1s. 6¾d. per quart, plus the cost of separation. Such cream, however, is commonly sold by retailers at 4s. a quart, or 6d. a reputed quarter-pint jar, which is equal to 4s. a reputed quart. Naturally, thick cream is frequently purchased, however, and thinned by the addition of milk before retailing. Where cream is removed by the separator, the quantity of fat left in the milk seldom exceeds 0·2 per cent., but where it is skimmed from the milk which has been set in open vessels the fat remaining may reach one-third of its total contents.

Why Cream Rises. The rising of cream is due to its lower density, that density varying from 1·000 to 1·016, so that, while it is lighter than milk, it is heavier than water. The practice of estimating the quality of milk by the aid of a *creamometer* is fallacious; this is owing in part to the temperature of the atmosphere, and in part to the individuality of the cows producing it. A tube in which milk is set may throw up cream of a high percentage, while the milk itself may be actually poor in fat. On the other hand, the percentage of cream may be low, and the fat yield high. Cream may be *pasteurised* for the improvement of its keeping properties, or it may be *separated* for the improvement of its quality.

Separated or Skimmed Milk. Separated or skimmed milk is that from which the cream has been removed, the first-named by the machine, the second by hand skimming. Its food value is practically maintained as equal to full milk by the addition of digestible fats or oils equivalent to the fat removed in the cream. Skimmed milk of average quality is composed as follows.

	Per cent.
Water	90 10
Fat	·75
Casein	3·50
Sugar	4·85
Ash	·80
	100·00

The density of skimmed milk varies between 1·033 and 1·037. If 10 per cent of water be added the gravity is reduced to 1·032, so that it then compares on this basis very closely with full milk. Separated milk possesses a slightly higher specific gravity than whole milk, containing, as we have seen, less fat. If skilfully mixed with rich full milk of low specific gravity it may be passed for whole full milk without detection.

Buttermilk. Buttermilk is the by-product left after churning cream or milk from which butter-fat has been removed. The quantity of buttermilk produced depends upon the quality of the cream. As cream is churned in a mature, ripe, or acid condition, buttermilk is acid, but it is a sound and wholesome food.

Whey. Whey is the liquid by-product of cheese-making. In skilful hands it contains but little fat, although large cheesemakers remove this fat by skimming for the manufacture of whey butter. Whey, however, is chiefly supplied to pigs, its value depending upon the large quantity of sugar which it contains. In an average sample the sugar present reaches 5 per cent., the curdy matter 1 per cent., the fat ·35 per cent., and the mineral matter ·76 per cent.

Milk Testing. The quality of milk is tested in various ways—by chemical analysis, by the Babcock and Gerber machines, the lactometer, and the creamometer. There are other methods which require technical skill, but in practice the amateur now depends chiefly upon the two first named. By *chemical analysis* the water is driven from the milk by heat, the dry matter remaining being the milk solids, which are separately determined. The method of determination, however, belongs to the department of chemistry. The *creamometer* is a glass tubular or cylindrical vessel 10 in. high by 1½ in. in diameter, although smaller and consequently less reliable tubes are sometimes used. There should be a scale on the upper portion of the vessel divided into 100 parts, beginning with zero near the top. The milk is poured up to this mark when quite fresh, and kept for 24 hours at an even temperature, as near 60° F. as possible; in due course the cream will rise, and the percentage can be read upon the scale. This test, however, as we have already shown, is not of a thoroughly reliable character.

The Lactometer. The *lactometer* should always be used in conjunction with the creamometer where that vessel is employed. This instrument is usually adjusted for use at 60° F. If gently introduced into milk at this temperature, the specific gravity will be shown. Thus, if the scale on the stem be level with the surface of the milk at the figure 30, the specific gravity is 1·030; but if the temperature be higher or lower, the specific gravity indicated will be higher or lower. The indication, however, will not be correct, and therefore a correction scale is necessary, in order that the exact gravity may be ascertained by referring to it. The best lactometers are fragile, the stem not exceeding ¼ in. in diameter, and the bulb 1½ in. by 3 in. in length. The most perfect lactometer is that invented by Quevenne.

The Babcock and Gerber Machines. The instruments invented by Babcock and Gerber are intended to determine the quality of milk by the extraction of its fat. The Babcock machine is a disc which revolves at great rapidity. Carefully measured quantities of milk are passed from a pipette into small bottles, the necks of which are graduated. These bottles are submitted to centrifugal force, when, by the aid of sulphuric acid, the casein of the milk being held in solution, the fat is driven into the neck of the bottle, and its percentage there read off. These machines are now generally used by advanced dairymen, and are of great value to the milk industry. The method of making the test, if the instructions sent with each machine be followed, is easily mastered. A number of samples of milk can be tested at one and the same time. Cream, buttermilk, skimmed milk, and whey may be tested by the same method.

From Farmer to Retailer. The bulk of the milk supplied to our large population is produced by farmers who contract to supply wholesale and retail buyers under conditions which are rearranged every half-year. There are, however, in or near all towns, cowkeepers who retail the milk they produce. The farmer is required to deliver his milk twice daily, well cooled, aerated, and sweet, containing at least 3 per cent. of fat—the Government standard—or slightly more in some cases, where firms require high quality. The milk is sent by rail, in metal railway churns, which usually hold 17 gals. imperial.

Milk Deliveries. It is the wisest and most business-like plan to deliver milk immediately after it has arrived from the station, servants and customers being advised, wherever possible, to take care that the vessels in which they receive it are perfectly clean and that it is always kept in the coolest dry apartment in the home.

JAMES LONG

Surgical and Medicinal Uses of Alcohol.
The Aldehydes. Acetic Acid and Vinegar.

THE PROPERTIES OF ALCOHOL

NEXT to water, alcohol is the universal solvent. It is invaluable as a solvent of varnishes, and, indeed, there are very few organic substances which are not more or less soluble in it. We may note alkaloids, volatile or essential oils, resins, iodoform, besides many other newer medicaments. Many of these organic substances are obtained in plants and have a medicinal value. Thus a very large number of drugs are administered in the form of alcoholic solutions or tinctures.

Alcohol an Antiseptic. Since alcohol is, in general, what we call a protoplasmic poison—that is to say, a substance which is deleterious to all forms of life—it is, of course, an extremely valuable antiseptic, and, as such, has certainly been used for ages. The classical instance of the use of alcohol in what is now called antiseptic surgery is, we think, the parable of the Good Samaritan, who, finding the stricken Jew by the wayside, " went to him and bound up his wounds, pouring in oil and wine " (Luke x. 34). Even at the present day alcohol is not infrequently used by the surgeon as a basis for various soaps for the purification of the patient's skin and of his own hands. It is also used in order to preserve various surgical materials. In the form of methylated spirit, it has long been employed as a preservative for dead snakes, pathological specimens, and so on. It was formerly used as an antiseptic in dyspepsia; but it is one of its properties, when highly concentrated, to interfere with the action of the ferments of the stomach, just as, after a certain point, it arrests the action of the ferment secreted by the yeast that produces it. Thus its medicinal value on this particular score is now discredited, seeing that the alcohol precipitates the pepsin or ferment of the stomach.

Local Actions of Alcohol. But alcohol has some other local actions in relation to living matter, these being dependent on its physical and chemical properties. It evaporates with extreme quickness whenever it is exposed, and thus, if it be applied to the skin, it has a marked cooling property, the transformation of the alcohol from the liquid into the gaseous form necessitating its absorption of heat or kinetic energy, according to the principles with which the student of physics has become familiar. On the other hand, the physical properties of alcohol may be differently used. For if it be applied to the skin and prevented from evaporating, its physico-chemical affinity for water manifests itself; it absorbs water from the tissues around it, and thus hardens them. It has the common action upon all living tissues of extracting water from them. Whereas it is a solvent for a very large number of organic bodies, it coagulates or solidifies albumin if it is able to act in strengths of 60 per cent. or upwards. Lastly, we may note, as a contact or chemical action of alcohol upon living tissues, that after stimulating the nerves of sensation it slightly weakens their sensibility; in other words, it is a weak local anæsthetic.

The New Science of Pharmacology. All over the world men and women are now studying the action of chemical bodies upon the various tissues and structures that are found in the living bodies of animals and plants. This new science is known as *pharmacology*. Its practical importance in medicine is, of course, obvious. Plainly; the doctor is more likely to use his drugs wisely in disease if he knows their action in health. It is from this point of view that pharmacology is commonly regarded. For instance, the local application of alcohol has a soothing action upon irritable tissues.

But, more widely considered, this practical aspect of pharmacology is seen to be a very small matter. When we come to think more consecutively, we see that pharmacology is really a new and immeasurably complex chemistry. Suppose, for instance, that it could be shown that the activity of the nerves depends upon a physico-chemical change in the albuminous matter of which they are composed—as in all probability it does—and that the action of alcohol, like that of so many other substances, in first stimulating and then depressing the activity of the nerves, could be shown to depend upon its precipitation of this albumin or these albumins; and suppose that this property of alcohol in this particular instance could be found to fall into line—as not improbably it does—with its action upon other living tissues (which all contain albumins), so that in one single statement there could be summed up a chemical explanation which would cover both the action of alcohol on the brain and its action upon the living cells of some humble plant—plainly this would be science of a very high order.

Chemical Substances and Living Tissues. This, indeed, is the kind of science which is now dawning.

There are quite a number of chemical substances which pharmacologists are coming to rank as *protoplasmic poisons*. Protoplasm, as the reader knows, is the name applied to the complex of chemical compounds which is regarded as the " physical basis of life " (Huxley), alike the life of a bacterium or the life of the body of man. It is of the utmost interest to discover that there are certain substances, such as antimony, arsenic,

alcohol, chloroform, carbolic acid, prussic or hydrocyanic acid—to name only a few out of a great host—which seem to interfere with the processes of living matter, to thrust a spoke into the wheel or cycle of its chemistry wherever it is found. Such facts must rouse our scientific interest. We are compelled to ask ourselves, in each case, what is the chemical explanation? We cannot help suspecting that it is one and the same explanation for the whole series of living forms when affected by a given substance—as, for instance, let us suppose, the interaction of alcohol and albumin, wherever albumin is found, or the action of alcohol upon the water which is present in all living tissues. Whether or not we are able to reduce the facts to a definite chemical explanation, they teach us, as their chief lesson, the common character, the essential unity, of protoplasm everywhere, so that, no matter where it occurs, a drop of prussic acid or alcohol or chloroform will form a definite reaction with it, just as hydrochloric acid and sodium carbonate or carbon and oxygen have definite relations with one another at all times and all places.

Opinion versus Science. It is partly in order to insist that the whole of pharmacology is really a special province of chemistry that we have made this digression, but partly, also, in order to give prominence to the fact that the pharmacology of alcohol, or the results of its chemical relationships to the various tissues and organs of the human body, is not nowadays a matter for individual experience or for mere opinion, but is a matter to which science has devoted very great attention for the last twenty years, and on which the most important conclusions have been reached. These conclusions are of the utmost importance—individual, national, racial, and even ethical.

A very large number of details in the pharmacology of alcohol are as yet incapable of a chemical explanation, and therefore in this place they must be ignored. But some of the most important of the properties of alcohol are strictly referable to chemical conceptions.

Alcohol and Temperature. For instance, it has long been known that alcohol reduces the temperature of the body. This it does in various ways, as, for instance, by sending a lot of blood to the surface, where it stimulates the nerves of heat and makes us think we are warm, whereas, of course, we are losing heat as fast as possible by radiation and conduction. But the most remarkable manner in which alcohol lowers the temperature is by interfering with oxidation in the body. This oxidation depends upon the properties of the red colouring matter in the blood, which, as the reader knows, is called *hæmoglobin*. For convenience this is symbolised by the letters Hb. As this Hb passes through the lungs, it becomes oxidised, forming a loose but definite chemical compound which is called *oxy-hæmoglobin*, and may be symbolised by the formula HbO_2. We dogmatically assert that this is a true compound, because, when we examine venous and arterial blood by means of the spectroscope [see PHYSICS], we find a definite and constant difference between the spectrum of the hæmoglobin in the one and the oxy-hæmoglobin in the other. There can be no more final proof that the oxygen has formed a compound with the hæmoglobin in the case of the arterial blood. We know, of course, that this compound has a brighter colour. The whole value of HbO_2 in the economy is that it is a readily decomposed compound, very easily giving up its oxygen for the purposes of the life of the tissues. Now, it has been clearly proved that alcohol increases the stability of HbO_2, with the consequence that the tissues are relatively starved of oxygen. Quinine and prussic acid have similar actions upon this compound. In the case of the latter, the decomposition of the oxy-hæmoglobin is absolutely arrested, and death ensues from what is, in effect, none other than suffocation. The continued ingestion of considerable quantities of alcohol tends to interfere so definitely with the oxidation of the bodily tissues that the fats of the body accumulate, and the patient becomes the subject of a morbid stoutness.

Oxidation of Alcohol. And this leads us to a new and still more interesting aspect of the subject. Everyone knows that alcohol burns. We students of chemistry know, *a priori*, that it *must* burn, because we know its composition. In each molecule of alcohol there is already merely one atom of oxygen, which may satisfy the desires of two atoms of hydrogen in C_2H_6O, leaving four atoms of hydrogen and two of carbon unoxidised, and therefore combustible. Now, alcohol is not, of course, oxidisable at the ordinary temperature of the air. Just as in the case of coal or wood, one needs first of all to raise the temperature very considerably by means of a flame, and then the oxidation will occur—itself producing a temperature high enough to permit of its own continuance.

The probability, then, would appear to be that alcohol cannot be oxidised in the body, which, after all, has a temperature not so very much higher than that of the atmosphere. But, on the other hand, other factors than temperature may induce the oxidation—presumably, as will have occurred to the thoughtful reader for himself, by providing those unknown conditions which are necessary to oxidation and to the production of which high temperatures owe their power of inducing it. We must not, then, answer this question as to the oxidation of alcohol, even at the comparatively low temperature of our bodies, without using the experimental or *a posteriori* method.

Has Alcohol a Food Value? Our inquiry has an obvious chemical interest, but it has a very great human interest as well. This will be evident if we consider for a moment what is meant by a food. As the reader knows, food is a substance which either forms tissue or provides the body with energy—a substance which does neither may be a tonic, or a stimulant, or a poison, but not a food. Thus, in inquiring into the food-value of alcohol, we can lay down certain definite propositions. The first is that its chemical characters absolutely exclude it from

any possibility whatever of belonging to the higher order of foods—those which form tissue. Alcohol is not a constituent of protoplasm, and is not capable of being even utilised as a "brick" or ingredient in the making of any constituent of protoplasm. But, on the other hand, alcohol, in virtue of its chemical characters, is capable of oxidation if the conditions be favourable. We already know that the oxidation of carbon and hydrogen, as in a fire, yields kinetic energy in the forms of heat and light. The so-called chemical or potential energy of the elements involved has been transformed into kinetic energy. If, then, we can burn up alcohol in the body, the oxidation of its carbon will similarly evolve kinetic energy, which will yield heat or motion, or, in other ways, will serve the needs of life by providing the conditions which permit of its continuance.

Alcohol and Nervous Tissue. Now, it has been definitely proved that alcohol is capable of oxidation within the body, and the conditions and limits of this oxidation can be stated with considerable definiteness. In general, it may be said that the ingestion within twenty-four hours of 1½ oz. of alcohol will result in complete oxidation, provided that this very small quantity be taken in fractions at sufficiently frequent intervals and in much dilution. If these conditions be granted, no alcohol can be recovered; all has become oxidised and destroyed. It is quite evident that this small quantity, and the conditions under which it has to be taken for complete oxidation, correspond to the practice of only a very few persons. But, in any case, the oxidation of alcohol, in part, within the body is no proof of its utility. The same is true of morphine and many other poisons. In order to protect itself, the body partly excretes them, and partly burns them up. But they are not therefore foods in any true or useful sense.

For some chemical reason, which is as yet obscurely understood, alcohol has a greater affinity for nervous tissue than for any other.

Most important of all, however, in their bearing upon the normal reactions of alcohol within the body are these words, now well established, which were laid down by Professor Metchnikoff eight years ago:

"Alcohol, therefore, suppresses the natural immunity of rabbits towards the first vaccine of anthrax. This impairment of their resistance was manifested by the inactivity of their white blood-cells; thus the bacilli were permitted to multiply without being checked by a sufficiently strong phagocytic ['eating cell'] reaction. As has been established, the leucocytes are sensitive even to small doses of ethylic alcohol, and present a negative sensibility in the presence of this substance. Alcohol, therefore, has a harmful action on the agents of natural defence against infective microbes."

Tests for Alcohol. The most commonly employed test for alcohol is the iodoform test, which consists in the formation of yellow crystals of iodoform when alcohol is exposed to the action of iodine and caustic potash. A few crystals of iodine should be added to the fluid under examination, together with just enough caustic potash to decolourise the iodine. If the test-tube now be heated, iodoform crystals will appear. Another common test is the chromic acid test, the addition of a small crystal of the red bichromate of potassium, together with heat or sulphuric acid, yielding a green colour due to the formation of the chromate. These tests and various others must be combined, as no one of them is conclusive singly.

Amyl Alcohol. The only other member of the series of alcohols to which we need refer here is *amyl alcohol.* It is, of course, ethyl alcohol that we have been discussing some time back, but for convenience we dropped the specific name. The formula of amyl alcohol need not be again quoted. It is obviously the hydroxide of pentane, as ethyl alcohol is the hydroxide of ethane. The substance which usually goes by the name of amyl alcohol is really a mixture of two closely allied alcohols which are so nearly identical that they have the same formula. During the process of the rectification of ethyl alcohol there is left in the stills the product which is called fusel oil. This consists mainly of the two forms of amyl alcohol and also of propyl and butyl alcohols. The amyl alcohols have an apple-like odour, an oily appearance, and are only very slightly soluble in water. They are extremely poisonous, and in even moderate doses produce violent convulsions, together with mental disorganisation.

General Reactions of Alcohols. We have already emphasised the fact that the alcohols are a series which has a systematic and uniform character. For convenience we may return to ethyl alcohol, which, as usual, we shall simply call alcohol, and we shall find in it an adequate illustration of the behaviour of the other members of its series.

If alcohol be oxidised totally, as when a flame is applied to it, the products are, of course, carbonic acid and water. But it may be oxidised to a measure short of this, and so may its fellows. For instance, by various means one atom of oxygen may be added to one molecule of alcohol, with the result that two atoms of hydrogen are removed so as to form with the thieving atom a molecule of water. When alcohol has thus had two atoms of hydrogen removed from it, it is alcohol dehydrogenised, and a short name has been coined to express this conception of it. Hence we have the word *aldehyde,* the three syllables of which exactly express the process by which an aldehyde is formed. In short, an aldehyde is a dehydrogenised alcohol. Aldehyde has lately been found in the nervous system in delirium tremens, so now we know what the oxidation and long-asserted food-value of alcohol are worth.

Other Members of the Alcohol Group. But the process may go further. Yet another atom of oxygen may be inserted into the aldehyde, but in this case it does not thieve away two atoms of hydrogen, but finds a home for itself in the molecule, forming the compound

known as *acetic acid.* The following table gives the sequence in the case of the first two members of the series of paraffins :

Paraffin	Alcohol	Aldehyde	Acid
CH_4 Methane	CH_3OH Methyl Alcohol	CHOH Formaldehyde	HCOOH Formic Acid
C_2H_6 Ethane	C_2H_5OH Ethyl Alcohol	C_2H_3OH Ethyl Aldehyde	C_2H_3OOH Acetic Acid

etc., etc.

In the above we have not attempted to give the various formulæ in their more complex and instructive form. On the contrary, we have written them merely in such a fashion as to express in the simplest way the manner in which each of these stages is derived from the last. The reader will surely be impressed by the orderly and intelligible character of this part of our study, especially if he remembers that the above table deals merely with the first two lines of an indefinite number, each displaying the same orderly character.

Formaldehyde. The new substances which occur in the above table are all of them of very considerable interest. Perhaps formaldehyde is the most interesting of all, because it seems to afford a clue to certain of the most important stages in the cycle of life. It is plain that, from one point of view, formaldehyde might be looked upon as CH_2O. Directly we write the formula in this fashion we say to ourselves, Why, surely this is the simplest carbohydrate ! Does it not answer to the definition of carbohydrates upon which we have already agreed—substances the molecules of which consist of carbon, hydrogen, and oxygen, the two latter being present in the proportions in which they occur in water ? Now this leads us much further. We know that carbohydrates are formed by plants ; we know, furthermore, that they owe their existence in the plant to the activities of the green leaf. We know that under the influence of sunlight the leaf obtains nascent and elemental carbon from the carbon dioxide of the atmosphere. We know also that the plant always obtains abundance of water from the soil. Is it not, then, conceivable that the plant unites the nascent carbon with water to form methyl aldehyde or formaldehyde, which is, so to speak, the unit of the various carbohydrates which afterwards appear in the plant—sugars, starches, and so on ? May we not imagine that, for instance, six molecules of formaldehyde might be packed together so as to form a single molecule, which, of course, would have the formula $C_6H_{12}O_6$, the formula of glucose ?

A Suggestion to Remember. This is an extremely interesting, probable, and suggestive speculation, and should certainly be remembered by the reader. Its value is not in the least detracted from by the necessary qualification that, in the form in which we have stated it, it is somewhat too simple. Doubtless, for instance, when we write the formula of glucose or of any other carbohydrate, we ought to enclose the whole formula in brackets, and then append an *n* in order to indicate that we do not know how many times over these combinations of atoms must be taken in order really to constitute a molecule of the substance in question. This and similar qualifications are necessary, but the reader should always look upon methyl aldehyde as a substance which has a unique speculative interest attached to it. This speculation has been immensely strengthened by the discovery of formaldehyde in green leaves exposed to sunlight.

But this substance is also of the very greatest practical interest. Methyl aldehyde or formaldehyde is a gas soluble in water. The aqueous solution is usually known as formalin, and contains from 35 to 45 per cent. of the aldehyde. It is an extremely powerful and penetrating antiseptic, and is steadily coming more and more extensively into use for this purpose, and also as a substitute for alcohol in the preservation of specimens. In much greater dilution, formalin may be used as a mouth-wash, and attempts of uncertain value have been made to utilise it as an antiseptic within the body in the treatment of various germ diseases, such as consumption.

Formic Acid. Our table has taught us that when methyl aldehyde is oxidised still further it yields formic acid, and at this point, perhaps, we shall find a clue to the name *formaldehyde.* Formic acid is so called because it occurs in considerable quantities in the body of the ant, the Latin name for which is *formica.* Its constitutional formula is best written HCOOH. Remembering the general rule as to the relation between successive paraffins, we shall then be able to see that the best way in which to write the constitutional formula of acetic acid will be to add CH_2 to the H of formic acid, which will yield us the formula CH_3COOH. This, indeed, is the formula of acetic acid. Formic acid is found not only in ants but also in the stinging-nettle, of which it is the actual weapon. Special interest, of course, attaches to it because it is the first of the series of acids which are called the *fatty acids.* It may be prepared artificially in many ways, the commonest of which is to heat oxalic acid with glycerin. Formic acid is a mobile liquid which resembles water in many of its physical characters—for instance, its boiling and freezing point and its specific gravity are all very close to those of water. Potassium formate may be made by a remarkably simple synthesis—that is, by the direct union of carbon monoxide and hot caustic potash. The reader will find that the formulæ of these two substances, added together, constitute the formula of potassium formate.

Aldehyde. Just as ethyl alcohol is usually called alcohol, so ethyl aldehyde is usually called *aldehyde.* Its constitutional formula is better written CH_3COH, or, still better, for the matter of that, H_3CCOH, since this last form shows us how the carbon atoms are united together in ethane and any of the substances derived from it. This ethyl or acetic aldehyde is a colourless, volatile liquid, the boiling-point of which is 21° C., and the specific gravity ·78. It has a characteristic smell. It is an excellent solvent for various substances, such as phosphorus.

Aldehyde is most commonly prepared by the interaction of bichromate of potassium upon ethyl alcohol, which it oxidises, removing two atoms of hydrogen in the manner we have described. Aldehyde is by no means a stable body, since it undergoes oxidation on mere exposure to the atmosphere, with the formation of acetic acid.

Acetic Acid. The best way in which to write the constitutional formula of acetic acid is H_3CCOOH. Its relation to ethane and the intermediate bodies has already been stated, as also its relation to formic acid, the first member of the series of fatty acids. In considering the natural production of acetic acid, we find that we have to consider again a process of fermentation. The ethyl alcohol from which it was derived was itself produced by fermentation. If, now, another organism, called the *mycoderma aceti*, be allowed to act upon such alcoholic liquids as beer and wine, a new and further fermentation occurs. The reader will ask how this can happen if alcohol itself be, as we stated, an antiseptic. But it is only in very considerable concentration that alcohol is an antiseptic. The amount contained in a weak wine or beer is quite inadequate to protect itself from decomposition. This is why weak wines often have spirit added to them in order to make them keep. In consequence of the oxidation of the alcohol in a weak wine, there is produced practically a weak acetic acid, and this we usually call vinegar.

The process of the manufacture of acetic acid varies in different countries, according to the price of alcohol. If wine be cheap, acetic acid may be obtained from it by the deliberate conversion of wine into vinegar. The *mycoderma*, or vinegar-plant, is found in abundance on bundles of twigs, over which wine is made to run very slowly, with the practically instantaneous production of vinegar, which, as might be expected, still retains a certain proportion of the flavour of the original wine. On the other hand, malt vinegar is prepared from beer which is made to flow between beech shavings, on which, again, the vinegar plant grows. In England, where alcohol is dear, acetic acid is commonly obtained by the dry distillation of wood. The acetic acid thus obtained is, of course, very impure, and is named, in allusion to its process of manufacture, *pyroligneous acid—i.e.*, "fire-woody." This requires to be freed from wood spirit, tar, and other impurities. The process is commonly performed by the addition of calcium carbonate, so as to form calcium acetate, which is heated, with the result that the tar adherent to it is disposed of, and then the acetate is decomposed by means of strong sulphuric acid.

Pure acetic acid is sometimes spoken of as a colourless liquid, and sometimes as a colourless solid, since below 17° C. it is solid, and is then called *glacial acetic acid.* It readily mixes with water, ether, and alcohol, and is useful as a solvent. The acid has a number of uses, both in medicine and in manufactures. In consequence of its affinity for water, glacial acetic acid has a marked caustic action upon the skin. It is sometimes employed also for the destruction of small warts and corns, but cannot compare with radium for such purposes. Weak solutions of acetic acid or pleasantly scented vinegar are agreeable applications to the skin, which they tend to cool as well as to free from the unpleasant defects of excessive perspiration. The acid has considerable uses in relation to calico printing, and is employed in the preparation of its salts, the acetates, which are important in commerce.

Vinegar and Obesity. Perhaps the importance of the subject will excuse us for referring to the only fashion in which acetic acid is nowadays employed internally in medicine. It is true that the drinking of vinegar will lessen weight, and it is also known precisely how it acts. The drinking of vinegar only reduces the weight of the patient because it sets up a mild inflammation of the coat of the stomach, and thus acts as a check upon the absorption of food.

If, however, we turn our attention to such a salt as the acetate of potassium, which is without the local irritant action of acetic acid, or if we take such an example as citric acid, which occurs in oranges and lemons, limes and citrons, we find that these substances do tend towards the reduction of the bodily weight. It is a general proposition in physiological chemistry that the rate of oxidation—or, to use a more general term, of what physiologists call *katabolism*—varies directly as the alkalinity of the blood and the bodily fluids in general. Any substance, therefore, that makes the blood more alkaline tends to increase oxidation of superfluous fat, and so to counteract obesity; on the contrary, any substance which reduces the alkalinity of the blood will tend to lessen the rate of oxidation, and so to increase the accumulation of fat. If the blood be not alkaline, and definitely so, life cannot continue; "acidity of the blood" has no existence, but the alkalinity of the blood may be *more or less marked.* What, then, will be the effect upon the blood, and therefore upon the rate of oxidation in the body, of drinking a glass of lemonade? The inevitable answer would seem to be that the alkalinity of the blood would be lessened and oxidation retarded.

Acids that Increase Blood Alkalinity. Somewhat paradoxically, however, precisely the reverse is the case. Citric acid, its salts the citrates, the acetates, and other similar organic acids and their salts, actually increase the alkalinity of the blood, because they do not circulate in the blood as such; nor does citric acid, for instance, neutralise part of the bicarbonate of sodium in the blood, and thus lessen the alkalinity of that fluid. On the contrary, the citrate thus formed—and the same is true of similar salts—is known to be oxidised by the oxygen present, in the form of what we have recently referred to as HbO_2, or oxy-hæmoglobin, in the red blood corpuscles. The consequence of the oxidation is to convert these salts into definitely alkaline *carbonates.* Hence the ultimate result of taking such acids as that of the lemon is to *increase* the alkalinity of the blood, and therefore the rate of oxidation in the body, and the dissipation of any oxidisable material such as fat that may have accumulated in too great measure.

C. W. SALEEBY

THE OLD WORLD OVERMASTERS THE NEW

PIZARRO LAYS VIOLENT HANDS ON THE INCA OF PERU

THE VICTORY OF CORTES OVER THE AZTECS OF MEXICO AT OTUMBA

The Conscienceless Raiding of the Native American Kingdoms and the Fluctuations of Faith and Government in India

THE NEW WORLD AND INDIA

UNTIL the great voyage of Christopher Columbus in 1492, the continent of America was a world apart—entirely cut off, so far as we know, from the Western Hemisphere, though we may be inclined to believe that in dim, far-away ages the races by which she was populated had found their way thither from Asia. We have therefore said nothing so far of their story; in fact, it would be difficult to say that they had a story at all. Whatever ethnology may teach us in the course of time, all we can do for the present is to divide the peoples of America into four groups: the dwellers in the Arctic regions, whom we know as the Esquimaux, a form of their name derived from the French; the Red Indian tribes, spread over the greater part of the North American continent; the peoples of Central America, including Mexico; and the peoples of South America.

A People without the Horse and Iron. Among the most useful servants of man in his struggle with Nature and in competition with his fellow-men—and, indeed, his most useful tool in the same struggle, with the exception of fire—have been the horse and iron, but both were unknown to the indigenous Americans. It followed that American progress in the direction of civilisation was slow. So far as we can tell, the Egyptians and Sumerians, centuries before the building of the first pyramid, were in a more advanced stage of civilisation than any American people within a thousand years after the beginning of the Christian era. We may note that the name of Indian was bestowed upon them all inclusively by the first voyagers to America, who were under the impression—an impression under which Columbus himself died—that they had sailed across the Atlantic to the Indies themselves. Hence it is that we still speak of the Red Indians and of the West Indies.

Backward State of the American Race. Even after the year 1000, it was only in Central America and in the northern and western regions of South America that anything which can fairly be called civilisation had come into existence. The North American tribes were nomads, who only here and there were beginning to settle down to agricultural pursuits. The South Americans were fishermen and hunters, whose ideas of government and religion did not rise above fear of the authority of reputed magicians, and of the otherwise uncontrollable and unintelligible powers of Nature. They were barbarians, mild or savage, as the provisions of Nature made it easy or difficult for them to live, free from fierce battles with beasts of prey or with competing barbarians.

But in the centuries preceding the discovery of America by Columbus, the peoples of Central America had made further advances. Races who are called the Toltecs and the Mayas had advanced so far that they dwelt in cities, and built great temples adorned with strange carvings, which, to some eyes, present a resemblance to the work of Egyptian or Assyrian sculptors. When the Spaniards began to visit the mainland of America, the "Spanish Main," in the opening years of the sixteenth century, they found only traces of this bygone Maya civilisation. But something much more substantial, and having in it the promise of permanence, was already developed in two regions, as the Spaniards were informed—Mexico and Peru.

The Embassy of Cortes to Montezuma. Before the fifteenth century, Mexico had been organised into a state or kingdom, having in it growing cities. By the middle of that century, the Mexican king, Montezuma I., had made himself master of a great territory which could fairly be dignified by the name of an empire. If the Indians had not learnt the use of iron, they appreciated that of the precious metals, and Mexico was wealthy. Stories of its splendour reached the Spanish governor of the islands. He despatched thither an armed embassy, headed by Fernando Cortes. They were four hundred men, with a smaller band of natives in attendance; a tiny troop to effect a conquest, but they had horses, armour, and, above all, guns. Montezuma II., who was now ruling in Mexico, sent envoys to meet Cortes, who announced himself as the envoy of the mightiest of monarchs dwelling beyond the seas, sent to visit the mighty monarch of Mexico. Montezuma replied with a polite message and a present, but forbade the dubious stranger to enter his capital. Cortes disregarded the prohibition, easily scattered such bodies of natives as were sent to bar his advance, and when he reached Mexico Montezuma did not venture to resist his entrance.

The king was not to be persuaded to accept the Christian faith at a moment's notice, but he offered tribute and homage to the monarch whom Cortes represented. It was soon evident to the Spaniard that, whether by Montezuma's will or not, his position and that of his followers in Mexico was precarious; so he took the king prisoner, or at least held his person practically captive. Then there was a collision between the Spaniards and the natives. The popular wrath was rising against the strangers, and when Cortes bade Montezuma to show himself publicly, and declare his friendly disposition towards his captors, the popular wrath was turned upon the unfortunate king, who was so seriously injured that he died shortly afterwards.

The Annexation of Mexico. In such circumstances there was but one course possible to Cortes. He and his little band cut their way

out of the city, where otherwise they must have been massacred. But he found ready support from the remoter tribes to whom the Mexican rule was a bloodthirsty tyranny. When he reappeared before the city, the Mexicans realised that resistance was useless, and Cortes proceeded to establish and organise a government in the name of the king of Spain—who in the same year had been elected German emperor. Sufficient reinforcements were sent, as a very few armed Spaniards were more than a match for thousands of the half-armed natives; and Mexico was permanently attached to the Spanish dominion.

The Peaceful Empire of Peru. Fourteen years later, in 1533, a like fate befell the Inca empire of Peru at the hands of Pizarro, a daring and unscrupulous adventurer of a very different type from the knightly Hernando Cortes. How long the Peruvian empire had existed, it is impossible to say. Some centuries at least before, the ruling race, the Incas, had appeared, according to tradition, from some unknown region, among the natives of the west coast and the mountains which border it, calling themselves the Children of the Sun. They were strangely free from barbaric traits. Their forces were better organised, and they proved themselves much more skilful warriors than the natives, but they did not use their superiority to devastate, to slay, or to enslave. They organised the government which they retained in their own hands after a strangely enlightened fashion. They proclaimed their intention of ruling, not as tyrants, but for the benefit of their subjects, and they lived up to their promises. In the fifteenth century there is every reason to believe that their empire was flourishing, peaceful, and happy. Undoubtedly it was enormously rich in mineral wealth, though the people probably had little conception of the immense value attached to gold and silver and gems by the dwellers in another hemisphere.

A BEAUTIFUL STATUE OF BUDDHA

There was little enough communication between the people of Peru and the tribes who lay between them and the Spaniards. Still, there was sufficient for the rumours of their vast treasures to be carried down to the north-eastern coast. Stirred by the thirst for gold, the adventurer Pizarro conceived the idea of seizing the Peruvian empire in the name of his own master.

The Treacherous Seizure of the Inca Throne. He procured a commission from the Spanish Court, and started upon his adventure with two hundred men and some small cannon. He made his way down the Pacific coast till he reached Peruvian territory. At this moment the Incas had shown so much of normal human nature that the legitimate king, Huascar, had been deposed by his brother Atahualpa. The peaceful prince never dreamed of danger from the little band of strangers; he welcomed them, indeed, with an invitation to his presence, and when they came near his capital he went down to their camp, with a great and peaceful train, to greet them. The Spaniards, with an audacity as magnificent as their treachery was base, suddenly opened an attack upon their unsuspecting host. Their guns dealt destruction: before the charge of their armed horsemen the Peruvians fled and were cut down like sheep. Atahualpa himself was captured. In his helplessness he offered Pizarro an untold ransom. Pizarro accepted the offer, and the king was released. But the Spaniards learnt of Huascar's title to the throne. Deeming that they would get from him still more favourable terms, they began an intrigue with him and his partisans. Atahualpa heard of the plot and ordered his brother to be put to death, whereupon the Spaniards turned on him, and put him to death by strangling, as a usurper, after which they assumed the authority themselves in the name of the king of Spain. Those Christian conquerors proved themselves far different from the benign race of the Incas, and the promise of the Inca civilisation was entirely wiped out. In such fashion were Mexico and Peru brought into the general current of the world's history.

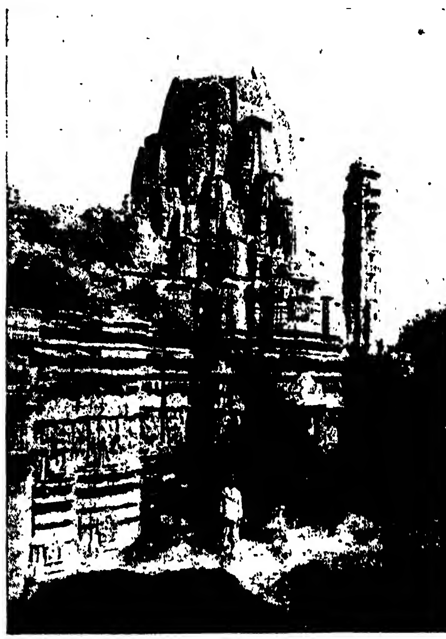
India Before the Mogul Period. In a somewhat less degree India also had hitherto

stood outside that current. Our mention of it has only been incidental, when Alexander the Great carried his arms into the Punjab, or when Mahmud of Ghazni led his Moslem followers to destroy Hindu idols and temples, and to denude them of their vast treasures. But during the sixteenth century India became the sphere of an empire the most magnificent, and by no means the worst ordered, in the world; and it is now time to give a brief sketch of her history before the Mogul period.

More than a thousand years before the beginning of the Christian era, the Aryans had established themselves in the upper plains of the Indus and its tributaries, which we call the Punjab, "the land of the five rivers." Perhaps before, but certainly not long after, the year 1000 B.C., they pushed on over nearly the whole of the Ganges basin, and were dominating the northern half of India, which alone should properly be referred to as Hindustan, though that term is, on the one hand, more particularly applied to the Ganges basin itself above Bengal, and, on the other, is commonly enough used in England to denote the whole peninsula. For convenience we shall refer to the northern half of India as Greater Hindustan, in contradistinction to the southern half, or Deccan, while we shall refer to the more limited area as "Hindustan proper."

The Aryan Distribution. Aryans appear to have penetrated only to a small extent into the Deccan. In the Punjab and in Rajputana, the whole of the north-west, they became so far dominant that there is probably only a small admixture of the indigenous races to be found among them. In Hindustan proper, the modern types show not much either of the pure Aryan or of the pure Dravidian, but rather of the combinations of the two stocks in varying degrees. The conquering race held itself apart, claiming a superiority both in this life and in the life to come, for the three social groups into which it was divided—the Brahmans, who were primarily a priestly group; the Rajputs, primarily a fighting class; and the Vaisyas, the merchants, mechanics, and tillers of the soil. The conquered Sudras formed the fourth, or in effect slave class.

At the time of the first conquest these divisions were by no means rigid, though very soon afterwards they became quite definitely marked, the Brahmans seeking to emphasise them on the hypothesis, not unusual when once a priesthood has begun to hold itself separate, that they themselves had a Divine authority setting them apart. But celibacy did not form part of their doctrine, and the separation was maintained by the prohibition of intermarriage between Brahmans and their secular countrymen. Similarly, the warrior caste, for social reasons, held itself aloof, and the Brahmans were ready enough to provide all sorts of religious sanctions for preserving distinctions of caste.

INDIAN ARCHITECTURE AT CHITOR, SHOWING ON THE RIGHT THE TOWER OF VICTORY ERECTED BY THE RAJPUT RANA KHUMBO TO CELEBRATE HIS DEFEAT OF MAHMUD IN 1440

The Rivalry Between Brahmanism and Buddhism. Probably about the sixth century B.C., the Prince Sakya Muni, better known by one of his assumed titles, Gautama, and best of all as Buddha, "the enlightened," appeared as a religious teacher who laid the foundations of the doctrine known as Buddhism. Buddhism ignored or denied Divine authority for social distinctions. For a period of perhaps a thousand years Buddhism was dominant, though Hinduism

was not crushed. During that time we hear of great kings—Chandragupta, king of Magadha, on the Middle Ganges, who extended his dominion over the Punjab, just after Alexander's invasion; his grandson, the great Asoka, a sort of Indian Alfred the Great; then, centuries later, another Chandragupta. But about the fifth century A.D. Brahmanism triumphed over Buddhism, which was driven almost entirely out of India, though it found a permanent home among the Mongolians of Burmah, Tibet, and China, and perhaps today numbers more adherents than any other religion.

The Establishment of Caste. With the triumph of Brahmanism came the development of the Hinduism which we know. The old divisions of castes based upon colour or race survived, but in the last thousand years it had become at least largely fictitious. The races had become mixed; in the Deccan the Brahmans had not kept their caste pure, and everywhere there were swarms of claimants to the name of Rajput who probably had very little Rajput blood in their veins. Tribal differences, continuity of occupation through generations, survival of the worship of local deities, and other influences had combined to make up within the greater castes innumerable minor castes, always with the tendency to prohibit intermarriage, and to distinguish still fresh castes as the outcome of intermarriage. Such, approximately, would seem to have been the origin of the caste system as we know it in India, though we have to add to this account that Brahmans and Rajputs continued to insist upon the purity of their own descent, probably with little justification outside of Rajputana.

The Advent of Mohammedanism. In the seventh century of our era, then, India was divided into Hindu kingdoms whose dynasties and boundaries shifted kaleidoscopically from generation to generation, as one or another expanded into an empire or contracted into a petty principality. In the eight century the Mohammedan Arabs broke into the north-west, and occasionally set up a brief dominion within a limited area. With the opening of the eleventh century came the series of tremendous incursions conducted by Mahmud of Ghazni, who, however, made no attempt to organise an Indian empire, though his lieutenants exercised his authority in the Punjab.

The power of the Ghaznavides in Central Asia was destroyed by the coming of the Seljuks. By the end of the century their hold even upon Ghazni itself was precarious, though they were still more or less kings in the Punjab. During the twelfth century their principal rivals and antagonists were the chiefs of the House of Ghor. Towards the end of the century they were finally wiped out by Ala-ud-Din of Ghor, who gave Ghazni to the flames and mastered the Punjab. Then came the great conqueror Shahab-ud-Din of Ghor, who saved himself from the onslaught of Genghis Khan by a timely submission which left him free to extend his own conquests. Before his death in 1206 he had established the Mohammedan dominion, with its centre at Delhi, which extended from Afghanistan over the whole of the Upper Ganges basin, and thus began the Mohammedan supremacy in the Indian peninsula.

Dynasties that Reigned in Delhi. After his death there followed a succession of rulers known as the Slave dynasty. As the father and predecessor of Mahmud of Ghazni had been a slave who rose to power in accordance with the immemorial Eastern custom of raising slaves to high positions of trust, and even to the command of great armies, so Shabab-ud-Din, otherwise called Mohammed Ghori, was succeeded by the slave Kutb-ud-Din, who had deservedly been one of his most trusted generals. Kutb-ud-Din did not, in fact, found a dysnasty; he reigned at Delhi while other portions of Shabab-ud-Din's empire fell under the sway of other generals.

The series was brought to an end by the establishment of the Khilji dynasty, of Afghan stock. The mighty Ala-ud-din Khilji not only established his dominion over practically the whole of Greater Hindustan, but extended it into the Deccan itself. In the next generation the Khiljis were displaced by a Turkish dynasty, the Tughlaks, who still further extended the supremacy of the Mohammedan princes of Delhi till nearly the whole of the peninsula owned them as its overlords. Yet even before the year 1350 the unwieldy empire held together by nothing but the power of the Delhi armies was breaking up; the Hindu princes of the Deccan were asserting their independence, and Bengal had broken free from the yoke. The power of the Tughlaks was entirely wrecked by the great invasion of Timur in 1398. The short-lived empire of Delhi was brought to an end.

Changing Fortunes in a Divided Land. Timur was a raider and nothing else, like Mahmud of Ghazni, a destroyer, but not a builder. Once more India became simply a congeries of kingdoms, owning no common authority, ever expanding and contracting. In Greater Hindustan the supremacy was generally held by Mohammedan princes; Delhi remained the seat of Mohammedan power, first under a Seiad dynasty, who claimed descent from Ali, the son-in-law of the Prophet, and then under the Afghan Lodis, who again held the Punjab as well as the Upper Ganges district.

In Rajputana, however, the Hindu princes shook themselves completely free from the Mohammedan dominion. In the Deccan there were for a long time two rival powers, the Mohammedan Bhamani dynasty and the Hindu kingdom of Bijanagar. But before the end of the fifteenth century the Bhamanis had extended their lordship over Bijanagar, although their dominion was in its turn broken up into states chiefly under Mohammedan dynasties, of which the greatest three were Bijapur, Ahmednagar, and Golconda.

Such was the condition of India when the most picturesque of conquerors, Babar, invaded Hindustan from Afghanistan, and laid the foundations of the Mogul empire. But already the great voyage of Vasco da Gama had opened to the Western nations a new highway to India, and the Portuguese had established their first settlements on the western coast of India and on the Persian Gulf.

A. D. INNES

Utility of Tramways. Bed, Rails, Rail Joints, Crossings, and Paving. Tramway Construction Costs.

TRAMWAY CONSTRUCTION

THE distinction between a tramway and a railway is hard to define. The word *tram* first appeared in the engineering world as the name given to a sort of waggon used for coals, and a tramway was a *way* for such a waggon. Historically, tramways came first, and the railway is, in fact, a development from the tramway.

The first tramways were rails of timber laid from various collieries to the nearest wharf exactly straight and parallel. As the wood was quickly worn by the rough traffic, wooden rails were nailed on the top of the others, and could be easily detached and renewed as required. Then wrought-iron laths were introduced for the like purpose, but without much advantage to economy on account of the high cost of the metal.

The First Tramway. In 1767, from some adventitious circumstances, the price of pig iron became very low, and the Coalbrookdale Iron Company, in order to keep their furnaces in, thought it would be the best means of stocking their pigs to lay them on the wooden rails, as this would help to pay interest, by reducing repairs of the rails, and if the price of pig iron rose, the pigs could be taken up and used as cast iron. This is a good illustration of how the development of the construction of ways of communication is governed by the relative cost of materials.

With the invention of the steam locomotive, which required a road to itself, tramways almost disappeared from this country. They were no longer wanted for the collieries, and on the ordinary roads the public would not have them.

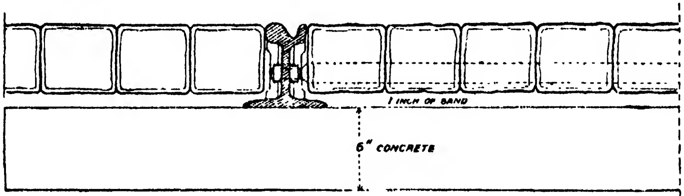
In America, however, where ordinary vehicular traffic was but meagrely developed, tramways grew up freely, and underwent many modifications and improvements as the use of iron and steel increased. They were introduced into English cities by an American engineer, Mr. G. F. Train, during the 'sixties, in spite of great opposition.

What is a Tramway? As now used, the word tramway may mean a light, temporary railroad used by contractors for various purposes; a permanent railroad of narrow gauge within the precincts of a factory or colliery; or a railway laid level with the surface of an ordinary road, so that other and unadapted vehicles can move freely over it and across it. In the United States of America, however, the last of these is more commonly described as a *street railway*, in many respects a preferable term.

A tramway will generally, therefore, differ from a railway mainly in the following respects—lighter loads, slower speeds, more frequent service, sharper curves, and steeper gradients. All these have modifying effects upon construction.

Street Railways. The design of these must provide that the special rolling stock will be confined to the rails, while all other vehicles are free to move on and off. An infinity of devices have been proposed and tried to effect this object economically. By process of survival of the fittest, the form of rail shown in **73** is now most generally used, together with wheels having flanges on the inside as described for rolling stock of railways.

Unsettled Ground. In cases where a tramway must be laid upon ground which cannot be relied upon to sustain the traffic permanently, it is best to adopt the sleeper construction, as for an ordinary railway. Then, when and as the settlement proceeds, the paving of the road may be taken up and the level of the rails raised by packing more ballast beneath the sleepers.



71. SECTION OF TRAMWAY SURFACE AND RAIL

Usual Construction. Under ordinary circumstances, the rails are laid upon a bed of concrete about 6 in. thick, more or less, as conditions require [**71**]. The photographic reproduction [**72**] illustrates a tramway line under construction. It must be seen, however, that the concrete itself rests on a solid, compacted foundation, so that it shall not be subjected to irregular cross strains sufficient to cause cracks. The concrete may be fortified by introducing iron rods into the lower layers while it is being put in. Such rods may be ½ in. or ⅝ in. in diameter, and laid both longitudinally in the direction of the rails and transversely to them. In this connection the articles on reinforced concrete construction [page 1375] should be consulted.

This rigid method of construction is very suitable to the streets of towns, but, as readers

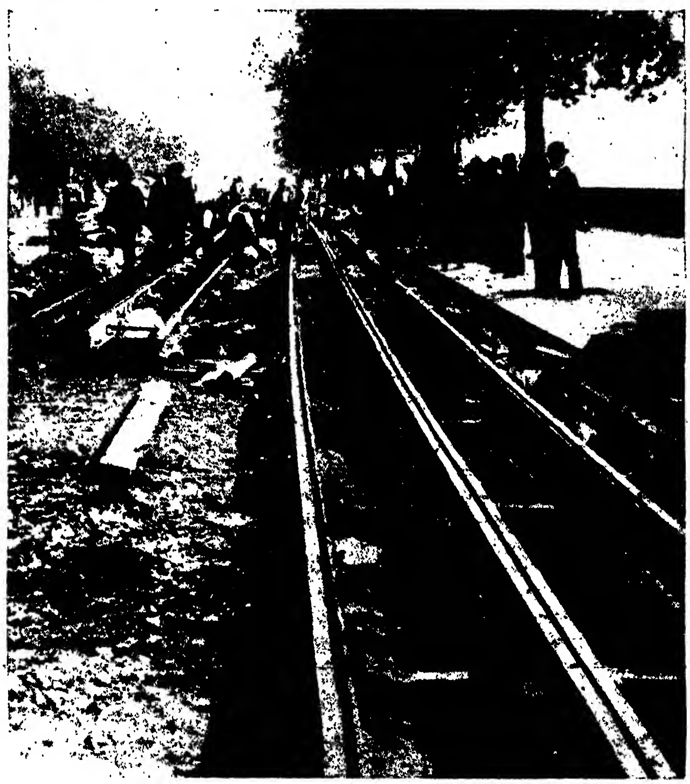
of the foregoing will readily appreciate, it is possible only on account of the comparatively light loads and slow speeds to which the tramlines are liable. And already in cities where the speed and weight of the tramcars are more than the average, its disadvantages are becoming apparent. It suffers much from the hammering effect of the wheels, and immediately any part is loosened, the hammering or pounding becomes aggravated at that place, rapidly causing destruction of the part. The introduction of wood between the rails and the concrete is therefore desirable where heavy traffic is anticipated in order to provide sufficient "give" to absorb the shocks.

The concrete may consist of four parts broken stone, two parts sand, and one part cement. The chief advantage of concrete beneath a street is that a uniform profile is more easily maintained upon the surface, which assists drainage and has the good appearance which the public demand.

Laying the Rails. The setting of the rails upon the concrete may be done in several ways. After the concrete is set it will always be found that the surface is not true enough to enable a rail to be simply placed upon it. The concrete may therefore be laid within a short distance of the level of the base of the rail and the intermediate space—say an inch — made good by blocks or wedges. Then, when the rail is in position, the space may be completely filled in with fine concrete. In places where the concrete is unduly high this is not always easily done, and then there remains but a thin, imperfect layer of cement, very liable to crumble under the traffic.

Granite chips are sometimes introduced to fill the space, or the rails may be placed first in their correct positions, and held by temporary supports, while the concrete is put in beneath them and carried up over the base of the rail, so as to include it. To effect this the concrete must be rather wet, and care must be taken that it is well worked in beneath the rail and smoothed off before it sets. If wood be used as a cushion beneath the rail, the laying of the concrete is done in the same way, except that it is seldom carried above the level of the bottom of the wood. The wood is commonly made 7 in. wide and 4 in. deep, and should, of course, be thoroughly creosoted. One of the objections to concrete beneath the rails is the time required for it to set; this greatly interferes with rapid completion of the work, since it would be its destruction to allow traffic to begin until the cement had hardened. There is, consequently, a great temptation to use very quick-setting cements for this work, whereas the cements that show the greatest durability are slow-setting cements.

The gauge in a tramway of this kind is not so easily defined as on a railway, on account of the wheel flanges running in a groove. To take rolling stock as made for a railway of the same gauge, the distance from the outside edge of one groove to the outside edge of the other should be half an inch less than the railway gauge, and the groove rather larger than it is ordinarily permitted to be made for tramways. The gauge is maintained by tie-bars, placed at intervals of 6 ft. or more between the rails. See the half section in 71.



72. CONSTRUCTION OF A CONDUIT TRAMWAY

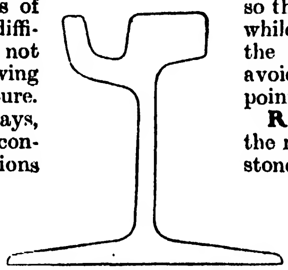
Rail Joints. The joints of the rails are even more troublesome upon a tramway than on an ordinary railroad, since they are covered up and inaccessible, except at the cost of taking up the roadway. Sometimes boxes are provided alongside to enable them to be got at, but unless the boxes are large enough to enable the whole of the joint to be examined, and the bars to be removed and replaced, they are not of much benefit.

When a joint becomes loose, dirt and grit work in between the parts and prevent any

efficient tightening up, so that the parts must be taken out and cleaned before being tightened.

The rail joints of a tramway may be examined by placing on the top of the rail, over the joint, a straight-edge 5 feet long. If a depression of as much as $\frac{1}{16}$ in. appear at the joint, it must be seen to. Another system that does not necessarily exclude the above is to overhaul thoroughly all joints at regular intervals—say, once a year.

One advantage of having the rails hemmed in on both sides by blocks of wood or granite setts is that the difficulty of making good joints is not complicated by the necessity of allowing for the expansion due to temperature. As the track cannot move sideways, the only effect of expansion or contraction, under the ordinary variations of temperature, is to produce stresses of tension or compression in the rails themselves, which they are well able to sustain.



73. TRAMWAY RAIL

Continuous Rails. The rails may therefore be made continuous by welding each one on to the next, so that there are really no joints at all. The welds may be effected by means of cast iron, by electricity, or by *thermit.* The first requires a miniature blast furnace to produce the cast iron, the second a formidable electric apparatus, but for the third only a few pounds of mixed ferric oxide and finely divided aluminium are wanted. This mixture, on ignition, supplies a quantity of superheated molten iron, and by means of this a very intimate union is effected between the two rails. The chief drawback rests in the possibility of failure. Bad workmanship on an ordinary joint may be rectified without much trouble, but if a weld fails the ends of two rails are ruined. The heat involved in a weld is so great that time must be allowed, before proceeding too far, for cooling to take place, with its accompanying contraction of the rail. This somewhat limits the speed with which a tram-line can be laid with welded joints under this system.

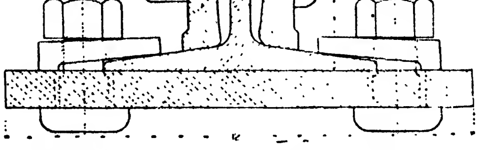
Points and Crossings. The curves and angles being necessarily sharper upon street railway than upon an ordinary railway, the points and crossings cannot be straight; they must in all cases be specially constructed to the angle and to the degree of curvature to be laid out in the place they are to occupy. This special construction takes time, and all frogs and similar fittings that must be specially made should be ordered from the manufacturers as early as possible, as the completion of the work is necessarily delayed until they are delivered and put down.

Whether for facing points or trailing points, a single tongue is sufficient, and most commonly used. Its use obviates the need of a pointsman, except in times of very heavy traffic.

On less frequented roads, the motorman stops just over the point as he comes up to it, and, leaning over the dashboard, can alter its position by means of a hooked end iron hanging there for the purpose. The actual point in the frogs and other parts liable to special wear are usually composed of specially hardened metal, and the groove may here be made more shallow, so that the wheels roll on their flanges while passing the gap, and thus diminish the bump, which cannot be entirely avoided with fixed facing or training points.

Resistance. When the groove of the rail becomes choked with dirt and stones, the wheel flanges grind upon it, and this effect, together with the friction on the sides of the flanges of the wheels, causes the resistance to traction on such tramways to be double that on an ordinary line of railway.

Paving. The paving of the road between the tram-lines and on each side of the rails is a matter of great importance to the proper maintenance of the way. Wood paving is often insisted upon, and there is danger that the swelling of the wood between two rails after prolonged rain should destroy the gauge by bending the rails or tilting them. When wood paving is used, it is therefore necessary to have substantial ties, placed closer together than would otherwise be necessary. The wood blocks will then sometimes arch themselves between the rails, causing a hollow beneath while the swelling lasts. For facility in making repairs, asphalt is to be preferred as a paving material; it is also to be preferred for hygienic reasons, giving less access to unwholesome organisms. But for durability and economy hard woods give better results than asphalt, and a safer footing for the horse traffic. Granite setts are not tolerated in most towns on account of the noise made by the traffic over them. They form, however, one of the best defences to that most troublesome form of wear which is occasioned by the tendency of the other vehicular traffic to run close to the tram-rails.

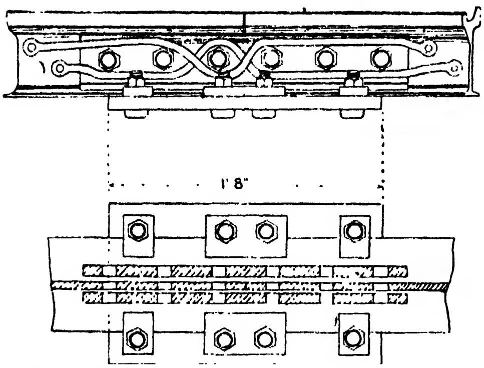


74. SECTION OF RAIL SHOWING FISHPLATE AND SOLEPLATE JOINT

The tram-rails themselves form a track of least resistance, at which the horse traffic seems to aim by getting at least one wheel on a tram-rail. Even if this be successful, unless the gauge of the vehicle is the same as that of the tram-line, the other wheel will be just off; and usually both wheels are running off and on all the time, causing excessive wear to the road in the neighbourhood of the rails, which is unduly expensive to make good.

Tramway Costs. The cost of laying a street railway will be approximately £4500 to £5500 per mile of single line. Of this, the rails and fastenings will account for 20 to 22 per cent.; special work in points, crossings, and the like, 9 to 10 per cent.; ballast, sand, and materials for concrete, 13 to 15 per cent.; paving materials, 29 to 32 per cent.; labour, 15 or 16 per cent., the remainder being miscellaneous.

Electric Traction. The introduction of electric traction, with its larger cars, heavier loads, and increased speed, has wrought a revolution in tramway construction. In all road tramways the rigidity of the bed is an essential factor in preventing disintegration of the paving, while on the other hand the rigidity of the track leads to excessive hammering and pounding of the rails and bed by the passing traffic. So far as the tramway is concerned, there are four distinct methods of electric traction—the overhead trolly system, the accumulator system, the conduit system, and the surface contact system.



75. PLAN AND SECTION OF FISHPLATE AND SOLEPLATE JOINT, SHOWING BONDING

Various Systems. The overhead trolley system is by far the most common. In this the electric current is conveyed along the route by bare overhead wires, from which it is collected by swivelling trollies on the vehicles, the return current being conveyed back to the generating station by the rails, which require to be specially bonded for the purpose.

In the accumulator system, the cars are driven by motors attached to the axles, actuated by the power from batteries. These are stored in boxes, generally under the car seats, and are charged at the power house. It is unnecessary to make any special provision in the track for this system, which is, however, now practically obsolete, owing to the excessive cost of maintaining the accumulator plates and the heavy dead load which has to be carried by the cars.

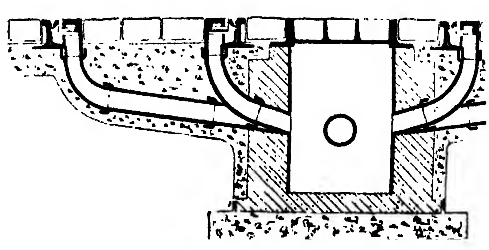
The conduit system is so called because of the conduit which is required to be constructed under the track, of which it forms a part, for the whole length of the tramway. This system is very expensive, by reason of the interference it causes with sewer manholes, gas and water pipes, and house services of all kinds. The London tramway system is the most extensive example of this mode of construction.

There are several surface contact systems, varying in details, but all have, on the surface of the roadway between the rails, a stud, or plate, which is energised as the car passes, and allows the current to be picked up by the vehicle. The plates are automatically de-energised after the car has passed, so that, unless the mechanism fails, there is no risk of shock to pedestrians and horses. The mechanism is very intricate, and the system is not largely adopted, the biggest mileage being at Wolverhampton, where the Lorraine system is employed.

Rail Joints. Ordinary fishplate joints which are satisfactory for horse traction are quite useless for electric traction. The simplest joint for electric traction consists of the addition of a soleplate [74 and 75] about 20 in. long, 12 in. wide, and 1 in. thick, secured to the under side of the flange of the rails by clips and bolts. The rails being usually 6½ in. or 7 in. deep, and the paving only 5 in. deep, the concrete road-bed covers the soleplate and flange of the rail, which is thereby to a certain extent anchored down.

The chief disadvantage of the soleplate is that it is almost impossible to pack the concrete solidly under the full width of the plate, even though it is tamped in from both sides. The plate, thus being only partially supported, springs as the load comes over it, and gradually works loose.

Bolts and Nuts. In order to facilitate the packing of soleplates the bolts are sometimes made with flat, oval heads, having a projection of half an inch or thereabouts. In this case the necks of the bolts are made oblong, instead of square, to strengthen the wide-spreading head. Bolts of the same type are also used to secure the fishplates to avoid excessive cutting of the paving around the projecting head. The flat head of the bolt is fixed on the outside of the rail, because on that side the fishplate projects almost to a line with the head of the rail; and as the paving must be laid close to the rail, a certain amount of undercutting of the former is unavoidable.



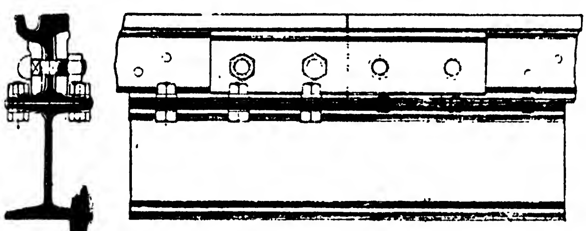
76. DETAIL OF SUMP AND RAIL DRAINAGE

The nuts used are almost invariably "lock" nuts. These nuts are prepared in a variety of patterns, and are so formed that they can be readily tightened up, but they bind on to the thread of the bolt and are difficult to loosen. Some of the nuts deform the thread, but many of the most satisfactory types do not injure it

at all. Steel of the very highest quality is used for the bolts. If soft steel is used there is a tendency for the joints to work loose by the stretching of the bolts under the strain. The dotted groove and guard of the rail shown in 74 indicate the special section used on curves of quick-radius to obviate the grinding action which would occur between the flanges of the wheel and the rail were the ordinary narrow groove employed.

Loose Rails. The working loose of rails or plates is a serious matter, owing to the difficulty of remedying the trouble. The first apparent result is a slight cracking or opening of the longitudinal joint between the rails and the paving, and this allows water to percolate through to the rail bed. As a car passes over this, water is "pumped" out, or forced from below the rail to the under side of the paving, which is raised slightly for the moment and falls back after the car has passed. Probably, however, some of the jointing material will slip out of the joint and lie under the paving so that it will not return exactly to its original position.

Grouting as a Remedy. The continuous repetition of this action soon causes the paving, for a width of perhaps one foot from the rail, to become so loose that individual setts or blocks may be picked out by hand. To remedy this state of affairs the whole of the loose paving is taken up and cleaned, the bedding material removed, and the concrete broken out about 6 in. wide and 1 in. deep below the flange of the rails. Liquid cement grout is then poured in while the rails are lifted to a slight extent to allow it to run underneath, the surplus being squeezed out as soon as the lever is removed and the rail dropped again. Great care must be exercised in doing this, particularly near the ends of the defective section, otherwise the adjoining rails will be loosened. The concrete bed is then made good again, and the paving relaid as before.



77. DETAIL OF RAIL-JOINT, SHOWING ANCHOR

This work cannot be done satisfactorily while the cars are running, and, even if done at night, the cement will not have hardened to a sufficient extent by the morning. To avoid this trouble altogether, elaborate systems of anchoring the track have been devised.

Rail Drainage. Considerable protection is afforded to the track by providing ready means for the removal of the rain-water which collects in the grooves of the rails and runs along the track to the low points where it forms pools. Rail drain boxes should be fixed at all low points, at intervals upon a long gradient, and also at intervals on a flat length of track, because the water cannot flow away, and therefore accumulates where it falls.

Rail drain boxes are of cast iron and oblong in shape; they fit underneath the guard of the rail and are bolted to the web [76]. They are sometimes fixed on the outer rails only, but it is better to provide one on each rail. The bottom part of the groove is cut out so as to form slotted holes about 4 in. long, having 1 in. of solid metal between each hole and covering a total length of about 16 in. When the rain, travelling along the groove, reaches these slots it falls through into the rail drain box, and thence to a sump or manhole in the centre of the track. The outlet from the manhole should be about 12 in. above the bottom, so as to provide capacity for the retention of the mud, which it is undesirable should enter the sewers. A disconnecting trap should be inserted on the pipe leading from the manhole to the sewer, so as to prevent emanation of sewer gas.

Bonding. As the rails are utilised to conduct the return electric current back to the generating station, it is necessary that the track should form a good continuous conductor of electricity. The fishplates are fitted tightly against the rails, but the areas of contact are small, and, consequently, at each joint there is an appreciable break in the continuity. To overcome this the rails are *bonded* by means of copper bonds, two to each joint, connecting the adjoining rails [75]. Holes for the bonds are formed in the webs of the rails, and rimered out bright and true to size. The head of the bond is then inserted and expanded by means of a steel pin driven into its hollow centre. A very close contact of copper to steel is thus obtained. When completed, the resistance of a length of two feet including a joint should not exceed and is frequently less than the resistance of a length of four feet of plain rail. At all points and crossings long bonds are fixed so as to connect the rails on either side; and cross-bonds are inserted at frequent intervals between the several rails.

Anchors. The tracks are anchored down by means of *anchors*, consisting of short lengths of H section steel, or of old tram-rails inverted and riveted or bolted to the under side of the rails [77]. The anchors are usually placed longitudinally with the track, under the joints and at intervals of about ten feet along the rails. The joint anchors which take the place of the soleplates are about 18 in. long, and the remainder 9 in. long.

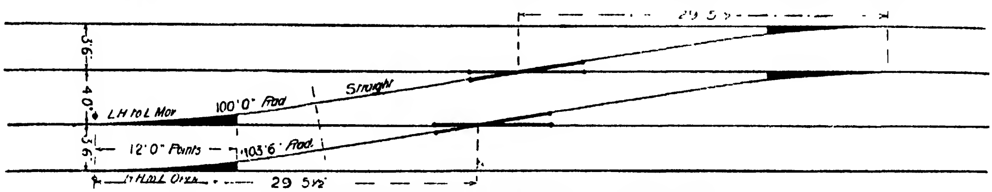
Junctions and Points. The points consist of steel castings with either movable or fixed tongues. They are usually about 12 ft. in length and curved to the same radius as that at which the branch line leaves the main track [78, 79 and 80]. The description "L.H. to L.Mov." indicates that the point is made to be fixed on the left hand—when standing in the

track facing the toes of the points—that one leg of the point curves to the left while the other one runs straight, and also that the tongue is movable. The companion point, "R.H. to L. Open," is fixed on the right-hand rail, one leg curving to the left, and the tongue being open or fixed—that is, it is a part of the casting.

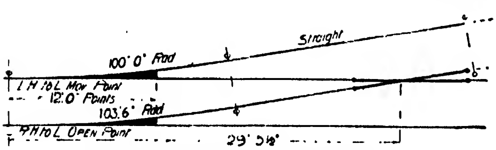
The movable points are fitted with a spring which keeps them fixed in whichever position they may be placed. By merely altering the position of the spring, the point can be converted into an automatic one. The tongue is then held against one side so as to turn all traffic entering the points into one branch, but the flanges of the wheels on the cars coming in the opposite direction can force the point open to allow them to pass, after which it springs back immediately to the normal position. The length of the lead and the angle of the crossing are dependent upon each other, and are designed to give smooth running.

Cost of the Conduit System. The excessively costly nature of the conduit system arises not so much from the expense of construction of the conduit but of the special work, such as the points and crossings at all junctions, and the crossover roads that connect the two tracks together at frequent intervals to enable the traffic to be diverted from one track to another in case of breakdown or obstruction. This special work frequently adds 30 to 35 per cent. to the cost of a scheme measured and valued as straight track throughout. [See ELECTRICITY, page 1818.]

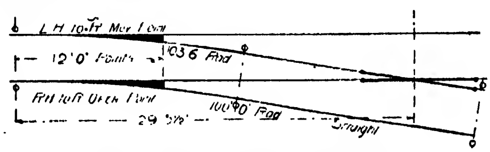
Construction of Conduit Tracks. In forming the track, cast iron yokes of H section are fixed at intervals of 3 ft. or 4 ft. The inner portion of the yoke, shaped to the cross section of the culvert, and the alternate yokes have long and short arms respectively. The long ones are used for supporting the rails which are secured between two projecting clips by



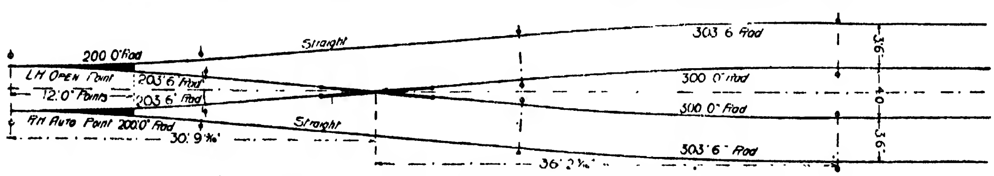
78. LAY-OUT FOR A TRAMWAY CROSS-OVER



79. A LEFT-HAND JUNCTION



80. A RIGHT-HAND JUNCTION



81. LAY-OUT FOR AN EQUILATERAL PASSING-PLACE END

Construction of Curves and Passing-Places. Curves are frequently *spiralised*—that is, they have an increasing radius as they approach the straight line, so that the change from straight to curve is almost imperceptible. Passing-places, also called turnouts, are placed on single track tramways to allow the vehicles to pass [81]. They are usually fitted with equilateral points, so that the centre line of the single track produced forms the centre line of the double track. The width of centreway between the two tracks depends upon the gauge of the tramway and the width of the cars; it must, however, be such as to give a clear space of 1 ft. 3 in. between passing cars. The length of the straight portions of passing-places is usually sufficient to allow two cars to stand without fouling the adjacent track. The standard gauge in London and many other towns is 4 ft. 8½ in.; a gauge of 3 ft. 6 in. is very common in the Midlands; and a 4 ft. gauge is also adopted in some places.

steel wedges driven between the flange of the rail and one clip. The slot rails are bolted to the top of each yoke. The slot rails have to be of sufficient strength to support the ordinary vehicular traffic of the road; they are sometimes, but not often, jointed with fishplates, similar to the rails. The tie-bars cannot be fixed from rail to rail in the usual way because the slot intervenes; they are therefore fixed alternately from the slot rail to the running rail and from the slot rail to the yoke. The yokes are embedded in the concrete tube which runs the full length of the track.

For conveying the electric current two bars of T section run longitudinally throughout the tube. These bars are supported on insulated brackets suspended from the yokes, and are bonded at the abutting ends of adjoining lengths. Surface boxes are provided to give access to each of these brackets, to the sumps, and to all other parts that may require attention.

American Writers. Ancient and Foreign Classics for English Readers. Books that Must, May, and Need Not be Read.

COMPARATIVE LITERATURE

WHAT is technically known as "comparative literature" is a vitalising factor in international goodwill and the fellowship of nations. To know only the literature of our own country is no small thing, but we must know also something of the other literatures, else we are in much the same position as the man who has travelled throughout these green islands of our race and has never set foot on foreign soil. He is the least competent person to tell us of his own land, lacking as he does all standards of comparison. The reader who knows only his national literature is not quite so insular, since he has at least spent time in the company of writers who, for the most part, reflect a universality of culture, but it behoves the serious student to acquire some knowledge of foreign literature, preferably in the original, even if his linguistic attainments be limited to one foreign language—French or German. There is, however, an abundance of good translations.

Thus, many of the best novels of recent years have come to us from France, Germany, Russia, and Italy. Some of the soundest criticisms of English literature are the work of French writers. In the study of comparative literature, the French are undeniably in advance of ourselves; and a few years ago a most useful treatise on the subject was written by M. Frédéric Loliée. This has been translated by Mr. Douglas Power, and published under the title of "A Short History of Comparative Literature from the Earliest Times to the Present Day" (Hodder & Stoughton. 6s.). There can be no doubt, of course, that it is best to read a foreign book in the language in which it was originally written, but the reader's knowledge of that language must be a competent knowledge. Where this is lacking, competent translations are the more desirable from every point of view. The English Bible is a translation, so we may well accept Homer at second hand.

AMERICAN LITERATURE

Although it is true in the main that American literature is only a province of English literature, we have not dealt with American writers in our preceding studies, reserving them for separate notice. Apart from the influences of environment, the sources of American literature may be truthfully described as English and German. In America of recent years there has been a much greater study of the Greek and Roman classics, while Transatlantic scholarship is rivalling that of England, particularly in regard to the literature of the Elizabethan period. We must now pass in review the names of those American authors with whose work every English reader should be acquainted.

Poetry. In poetry, the outstanding names are those of WILLIAM CULLEN BRYANT (b. 1794; d. 1878); RALPH WALDO EMERSON (b. 1803; d. 1882); HENRY WADSWORTH LONGFELLOW (b. 1807; d. 1882); JOHN GREENLEAF WHITTIER (b. 1807; d. 1892); EDGAR ALLEN POE (b. 1809; d. 1849); OLIVER WENDELL HOLMES (b. 1809; d. 1894); WALT WHITMAN (b. 1819; d. 1892); JAMES RUSSELL LOWELL (b. 1819; d. 1891); CHARLES GODFREY LELAND (b. 1824; d. 1903); RICHARD HENRY STODDARD (b. 1825; d. 1903); BAYARD TAYLOR (b. 1825; d. 1878); FRANCIS BRET HARTE (b. 1839; d. 1902); JAMES WHITCOMB RILEY (b. 1853); and CINCINNATUS HINER MILLER ("Joaquin Miller") (b. 1841; d. 1913). A number of these poets are no less, and some are more, distinguished as prose writers.

Prose Fiction. American prose is characterised by much didacticism; its earliest examples bear the impress of Steele and Addison and the Puritan divines. In its later phases it has, however, lacked neither fancy nor humour, the humour being especially racy of the soil. Perhaps no name more representative of American letters could be mentioned than that of "Mark Twain," SAMUEL LANGHORNE CLEMENS (b. 1835; d. 1910), who is essentially a humorist, with a vein of seriousness cropping out at times above the surface of his humour. The short story has been brought nearer to perfection in America than it has in England. Taking the writers of fiction in chronological order, the following may be accepted as representative: JAMES FENIMORE COOPER (b. 1789; d. 1851), author of "The Last of the Mohicans" and other tales of Red Indian life; NATHANIEL HAWTHORNE (b. 1804; d. 1864), author of "The Scarlet Letter"; OLIVER WENDELL HOLMES, author of "Elsie Venner"; EDGAR ALLEN POE, an absolute master of the short story; HARRIET BEECHER STOWE (b. 1811; d. 1896), author of "Uncle Tom's Cabin"; FRANCIS RICHARD STOCKTON (b. 1832; d. 1902), author of "Rudder Grange"; THOMAS BAILEY ALDRICH (b. 1836; d. 1907), whose "Queen of Sheba" is one of the greatest of short stories; WILLIAM DEAN HOWELLS (b. 1837), who shares with HENRY JAMES (b. 1843) the honour of being at the head of living American novelists, as Thomas Hardy decidedly takes the lead in England; GEORGE WASHINGTON CABLE (b. 1844), the author of "Old Creole Days"; JOEL CHANDLER HARRIS ("Uncle Remus") (b. 1848; d. 1908); FRANCIS MARION CRAWFORD (b. 1854; d. 1909), who, though born in Italy, and devoting his talents to the description of Italian life, may be ranked as an American; HAROLD FREDERIC (b. 1856; d. 1898); GERTRUDE ATHERTON; and

EDITH WHARTON (b. 1862), whose "Valley of Decision" and "House of Mirth" are among the best examples of the novel, while her tale "The Descent of Man" shows her to be one of the best of short-story writers now living.

Criticism and Philosophy. Of American essayists, critics, and philosophers, much might be written, especially of BENJAMIN FRANKLIN (b. 1706; d. 1790); WASHINGTON IRVING (b. 1783; d. 1859); RALPH WALDO EMERSON; JAMES RUSSELL LOWELL; OLIVER WENDELL HOLMES, and HENRY DAVID THOREAU (b. 1817; d. 1862). Of more recent writers, in addition to W. D. HOWELLS and HENRY JAMES, may be cited EDWARD EVERETT HALE (b. 1822; d. 1909); THOMAS WENTWORTH HIGGINSON (b. 1823; d. 1911), and CHARLES ELIOT NORTON (b. 1827; d. 1908).

Science and History. In the world of science the name of the Swiss naturalist JEAN LOUIS RUDOLPHE AGASSIZ (b. 1807; d. 1873) may be claimed as American. American historians of note include GEORGE BANCROFT (b. 1800; d. 1891); JOHN LOTHROP MOTLEY (b. 1814; d. 1877); WILLIAM HICKLING PRESCOTT (b. 1796; d. 1859), and GEORGE TICKNOR (b. 1791; d. 1871), whose "History of Spanish Literature" is one of the best works on that difficult subject. Some acquaintance with the works of every writer named is desirable in anyone who would be considered "well read."

ANCIENT CLASSICS

Greek Literature. An excellent little primer on the "History of Greek Literature" is that by Sir Richard Jebb (Macmillan. 1s.). The study will be the more profitable if it is made supplementary to a study of the history of Greece, for which purpose we would commend W. Smith's "Student's Manual of Greek History" (Murray. 7s. 6d.). One further point has to be borne in mind, and that is the importance of a knowledge of mythology. This in itself is a wide subject, but some acquaintance with it is a primary essential for all who wish to understand the language of the classics, modern as well as ancient. There is a useful little handbook of mythology by Thomas Bullfinch (Routledge. 1s.).

The student's next concern will be with particular authors: Homer, the father of the epic; Hesiod, poet of men, as Homer was poet of the gods; Theocritus, the writer of idylls; Pindar, the lyric poet; Æschylus, Sophocles, Euripides, the writers of tragedies; Aristophanes, the writer of comedies; Plato and Aristotle, the philosophers; Xenophon, Plutarch, Thucydides, and Herodotus, the historians; Demosthenes, the orator; Lucian, the satirist; and others. We know of no better introductions to the study of these masters than the "Ancient Classics for English Readers" (Blackwood. 28 vols., 1s. each). Of the "Iliad" and the "Odyssey" of Homer, Chapman's versions still maintain a general excellence despite many rivals; and we may here commend Gladstone's primer on Homer (Macmillan. 1s.). For texts and translations of the other writers we must refer the student to the catalogues of Messrs. Frowde, Macmillan and Bell.

Latin Literature. We know of no better introduction to the study of Latin literature than the manual by Professor J. W. Mackail (Murray, 3s. 6d.). But A. S. Wilkins's little primer (Macmillan. 1s.) and Smith's "Student's Rome" (Murray. 7s. 6d.) will prove most helpful. To come to particular works: The philosophical poetry of Lucretius; the lyrics of Catullus; the orations of Cicero; the epic strains of Virgil; the odes and satires of Horace; the voluminous verse of Ovid; the histories of Cæsar, Livy, Tacitus, Sallust, and Suetonius; the satires of Persius, Juvenal, and Apuleius; the philosophical writings and plays of the younger Seneca; the comedies of Plautus; the natural history of the elder Pliny; the epistles of the younger Pliny; the epigrams of Martial; the rhetoric of Quintilian; the writings of Tertullian, the first of the Latin Fathers—these, one and all, may well claim patient study. Apart from the catalogues of the educational publishers already mentioned, J. E. B. Mayor's "Bibliographic Clue to Latin Literature" will be found of material assistance to the student, whether the quest be a sound text or a competent translation.

FOREIGN CLASSICS

Italy. After a good grounding in the literature of Greece and Rome, the student will turn naturally to the literature of modern Italy, beginning with Dante, whose "Divine Comedy," written at the opening of the fourteenth century, links the ancient with the modern world, and marks the beginning of what is called the Renaissance. As a nucleus of this study, Richard Garnett's "History of Italian Literature" (Heinemann. 6s.) and Lewis Einstein's "The Italian Renaissance in England" (Macmillan) could not be improved upon, and much help through the tangled maze of an important period of European development will be derived from the abstract of John Addington Symonds's colossal history of "The Renaissance in Italy," written by Alfred Pearson (Smith, Elder. 7s. 6d.). One may trace the line of Italian literary development from Dante through the poetry of Petrarch, Ariosto, Guarini, Tasso, Marini, Alfieri, Monti, Manzoni, Leopardi, Metastasio, Carducci, and Rossetti; the tales and novels of Boccaccio, Bandello, Manzoni, Gabriele d'Annunzio, Verga, Fogazzaro, and Mathilde Serao; and the prose of Machiavelli, Guicciardini, Castiglione, Benvenuto Cellini, Bruno, Leopardi, Silvio Pellico, and Villari.

France. French literature is, from a strictly literary standpoint, of the first importance. One can have no more reliable guide in this study than Professor Dowden's handbook (Heinemann. 6s.) or Professor Saintsbury's "Short History of French Literature" (Clarendon Press. 10s. 6d.). Leaving "the shores of old romance" sacred to such works as the "Chanson de Roland" and the "Roman de la Rose," we may briefly indicate the vast stores of literary wealth in the language of our nearest neighbours by mentioning the

histories of Froissart, De Comines, Thierry, Guizot, Theirs, Michelet, and De Tocqueville; the poetry of Villon, Ronsard, Malherbe, Lafontaine, Boileau, André Chenier, Lamartine, Béranger, Hugo, Alfred de Musset, Leconte de Lisle, Beaudelaire, Théophile Gautier, Sully Prudhomme, and François Coppée; the wit of Rabelais, Voltaire, la Rochefoucauld, Chamfort, Marot, and Montesquieu; the philosophy of Montaigne, Descartes, Beyle ("Stendhal"), Rousseau, Condillac, and Condorcet; the plays of Corneille, Racine, Molière, Scarron, Crébillon, Beaumarchais, Sardou, Hervieu, and Maeterlinck; the thoughts of Pascal and Joubert; the novels and tales of Marguerite de Valois, Le Sage, Voltaire, Hugo, Bourget, Balzac, Boisgobey, Prévost, Dumas, Flaubert, Daudet, Zola, Merimée, Maupassant, the brothers De Goncourt, Murger, Georges Sand, Eugène Sue, Erckmann-Chatrian, Jules Verne, Pierre Loti, René Bazin, and "Gyp"; the letters of Mme. de Sévigné, Mme. de Staël, Mlle. de Lespinasse, and De Sénancour; the fables of Perrault and Lafontaine; the varied writings of Renan; the sermons of Bousset, Fénelon, and Massillon; the oratory of Mirabeau; the acute critical work of Sainte-Beuve, Boileau, Diderot, Taine, Faguet, Jusserand, and Brunetière. To the reader with a knowledge of the French language we would commend "Blackie's Little French Classics," in which the cream of the literature is reprinted and carefully annotated.

Germany. German literature is another vitally important section of European letters. It has had a profound effect on both English and American thought. It is rich in romance, poetry, history, philosophy, religion, fiction, and works for the young. The English student is advised to begin his study of the subject with two works by Professor Charles H. Herford —"Studies in the Literary Relations of England and Germany" (Cambridge University Press. 9s.); and "A Short History of German Literature" ("Heinemann. 6s.). First come the tales of the Nibelungs and the songs of the Mastersingers, which form such an important groundwork for modern German music, and especially the music of Richard Wagner.

Next in importance from a chronological standpoint come the sermons and other compositions in prose and verse of Luther, Zwingli, and their fellow Reformers. From this standpoint may be followed the course of German philosophy in the writings of Leibnitz, Kant, Fichte, Schelling, Hegel, Herbart, Schopenhauer, Von Hartmann, and Nietzsche; the evolution of poetry and the drama in the works of Klopstock, Lessing, Wieland, Herder, Schiller, Goethe, Bürger, Kleist, Körner, Arndt, Rückert, Uhland, Heine, Wagner, Kotzebue, De la Motte Fouqué, Chamisso, Sudermann, Hauptmann; the theological writings of Reinhard, Schleiermacher, Neander, Strauss, Dollinger, Ritschl, Wellhausen, and Haeckel; the historical studies of Gervinus, Ranke, Niebuhr, Boeckh, and Mommsen; the novels and tales of Goethe, Tieck, Novalis, Hoffmann, Jean Paul Richter, Auerbach, Gustave Freytag, Fritz Reuter, and Gottfried Keller. The philological and scientific writings of German origin are far too numerous even for the barest mention.

Spain. The literature of Spain is the theme of a well-written monograph by J. Fitzmaurice Kelly (Heinemann, 6s.). After consideration of the "Chronicle of the Cid," the oldest epic in a Romance language, and the romances of chivalry, such as the "Amadis de Gaula," the names that the English student can least afford to pass over are those of Montemayor, Cervantes, Lope de Vega, Mendoza, Herrera, Calderon, Camoens, Gongora, Juan Valera, and Palacio Valdés. It is in particular with reference to the history of the drama that Spanish literature is worthy of study. That its influence on English letters has been considerable may be gleaned from F. W. Chandler's "The Picaresque Novel in Spain" and J. G. Underhill's "Spanish Literature in the England of the Tudors" (Macmillan).

Russia. Russian literature, as represented in the work of Gogol, the Russian Dickens; Poushkin, Lermontoff, Dostoievsky, Turgenieff, Tolstoy, and Gorky, has exercised considerable influence on European literature generally. Charles E. Turner's "Russian Literature" and "Modern Russian Novelists" and Waliszewsky's "Russian Literature" may be consulted.

Scandinavia. Scandinavia is also playing a great part in the formation of modern literature. The dramas of Henrik Ibsen and the novels and plays of Björnson Björnstjerne represent Norway's contribution. Denmark can boast the powerful literary criticisms of George Brandes; and Holland the penetrating novels of Maarten Maartens.

WHAT TO READ

Books that Must be Read. The student who has companied with us thus far is already acquainted with the books which we consider must be read by all who desire to have a substantial knowledge of English literature. Here we purpose offering no more than a few concluding hints.

The obvious reply to the question, "What are the books that must be read?" is, "The Best Books." But "the best books" for one are not "the best books" for another. In the voice of many counsellors there is wisdom, but this wisdom has to be distilled by the person who hopes to profit from it.

This is but one of many reasons why we consider the lists of "the best books" that have been drawn up from time by time by well-known men are positively harmful if taken as of universal application. At the same time, it is quite obvious that, as Ruskin once wrote, "a well-trained gentleman should know the literature of his own country and half a dozen classics thoroughly." The rest may wait on inclination. We are at least on firm ground in saying that the study of literature for educational purposes is likely to be of the greatest value if it is based on a knowledge of literary

history. The course, then, which we advise the student to pursue is to acquire a good "grounding" in general history, and then to study a good handbook to literary history, such as the Lectures of Frederick Schlegel (a translation of which is to be found in "Bohn's Library") or the "Short History of Comparative Literature," by Frédéric Loliée, already mentioned. Among the other literary histories which will be found suggestive, a place may be claimed for Taine's "History of English Literature." In it the readers, while being taken over familiar ground, has the opportunity, of seeing the working of a characteristic French mind. It is necessary, however, in reading the book, to understand that Taine always builds upon a theory, and so marshals his facts that they fit conveniently into a proof of his theory. The theory underlying the History is that English literature is such a complete expression of English character that anyone who knows the English people might infer that the books would be written which have been written. When we are on guard against the theory, the arguments used become ingenious; and even amusing.

The books in English that must be read by everyone should include the Bible; Chaucer's "Canterbury Tales"; Spenser's "Faëry Queen"; the whole of Shakespeare; Milton's "Paradise Lost," "Comus," "Samson Agonistes," and the shorter poems; Bunyan's "Pilgrim's Progress;" Swift's "Gulliver's Travels"; Defoe's "Robinson Crusoe" and "Moll Flanders"; Goldsmith's "Vicar of Wakefield" and his two comedies; Sheridan's plays; Byron's "Childe Harold"; Scott's "Lady of the Lake," "Lay of the Last Minstrel," "Marmion," and all his shorter poems; Wordsworth, Keats, Burns, Gray, Tennyson, and Browning; Lewes's "History of Philosophy"; Gibbon's "Decline and Fall of the Roman Empire"; Bacon's "New Atlantis," "Novum Organum," and "Essays"; the Essays of Addison, Macaulay, Lamb, and Hazlitt; Green's "Short History of England"; Carlyle's "Past and Present," "Sartor Resartus," "Heroes," and "The French Revolution"; Mill's "Political Economy"; Boswell's "Life of Johnson"; the novels of Fielding, Scott, Kingsley, Thackeray, Dickens, George Eliot, Charlotte Brontë, several of Trollope, Meredith, and Hardy; and in foreign literature Homer, Plutarch, Virgil, Horace, Dante, Rabelais, Cervantes, Molière, Montaigne, Goethe, Schiller, Voltaire, Hugo, and Balzac.

Books that May be Read. Here we pass to less certain ground, but we may claim that throughout our studies considerable care has been taken to specify, as their names have occurred, the works of many great writers which might be left entirely to the inclination of the general reader, though imperative to the student. For instance, we would have every "well-read" man know the best plays of the Elizabethan dramatists, as these are to be found in the "Mermaid Series," but this, imperative to the student, is optional to the general reader. So with such classics as "The Wealth of Nations" and "The Origin of Species." The gist of Adam Smith's philosophy and of Darwin's science is absorbed in one's general reading; by which we mean that both of these writers have so influenced their contemporaries and their successors that few intelligent people of the present day are ignorant of their teachings, even though they may not have read their works. This is no excuse for neglecting either; but the man who has not read "Hamlet" or "Paradise Lost," let us say, has an unfurnished chamber in the mind, and this could not with equal force be charged against him who had not read "The Wealth of Nations" or "The Origin of Species." Beyond the minimum of "Books that must be read," which we have ventured to suggest above, the reader may be left to rove at will among the treasures of our literature, applying such knowledge as we trust he has acquired in these brief studies.

Books that Need Not be Read. We have indicated above that we not believe in any "best hundred books." A hundred books that have a universal appeal could not possibly be named by the most ingenious and omnivorous reader that ever attempted the task. Few books are so bad as not to generate one new thought in the mind of the reader; but so long as we can turn in a moment to any work which the verdict of time has placed among the great books of the world, we must not palter with the "unplaced" modern writer, unless we have for ourselves discovered that he has something to tell us for which we are the better, or which we want to know. Above all, if we have tastes in certain directions, let us develop them. Thus, if we delight in history, let us get through with Gibbon—a glorious task.

Finally, in history and science no book need be read whose author is known to be untrustworthy; in philosophy none that has not been accepted by the mass of thinkers; in religion, none whose author has not been noted for sincerity, and who could not have said with Whitman:

> "Camerado, this is no book;
> Who touches this touches a man;"

in biography, no book that is not the work of a writer noted for his care no less than his sympathy with literary grace; in poetry, none that has not touched the heart of a generation, or awakened the enthusiasm of the most cultured; in fiction, nothing that is not in the estimation of honest criticism informed with real character, fidelity to life, and charm of style, no matter how widely it may have been sold or is selling. All such excluded, there will still remain a sufficient number of great and enduring works of literature to occupy the most insatiable reader throughout a long life.

J. A. HAMMERTON

LITERATURE CONCLUDED

A Course in Journalism begins in the next Chapter in this Group.

Openings in British Colonies for Teachers, Nurses, Engineers and Surveyors, and Medical and other Officers.

COLONIAL MUNICIPAL POSTS

With few exceptions, municipal activities are naturally far less developed in our Colonies than in the ordered and close-knit life of the home country. But as the townships overseas grow in size and wealth, and the need for some sort of public control becomes increasingly evident, a system of local government grows up apace—based for the most part on English models—and affords employment for an official staff. To select a few striking instances, such towns as Melbourne, Wellington, Cape Town, and Johannesburg enjoy a municipal system of local service as fully developed in many respects as that of London; and examples are not wanting of Colonial corporations with profitable undertakings in gas, electricity, and similar "municipal trading" ventures.

Openings for Englishmen. For readers in this country the greatest interest attaches to the practical question, "What demand exists in the Colonies for municipal officers from England?" It must be admitted at once, in reply, that the general position in respect of municipal employment closely resembles that described in our preceding chapter with reference to the Government service. The colony itself, in a word, is usually able to meet its own demands for candidates.

But this rule is not without many exceptions. Owing mainly to the local lack of training facilities, the leading Colonial towns apply from time to time to English sources for suitable officers; and particularly for such skilled servants as school teachers, nurses, medical officers of health and sanitary inspectors, and municipal engineers and surveyors.

In such cases the selection of a suitable English candidate is usually entrusted by the corporation concerned to its agent in London, who advertises the vacancy either in an organ of the particular calling from which applications are sought, or in one of the weekly or monthly papers devoted to municipal affairs. Among publications of the latter class, that in which announcements of Colonial appointments most frequently appear is probably the "Municipal Journal," published at Sardinia House, Sardinia Street, London, W.C.

Public School Teaching. The department of public education, which in some corners of the Empire is in the hands of the responsible Government, but is generally controlled by urban or district authorities, affords greater scope for candidates from Great Britain than any other branch of the Colonial public services. Not that teachers from the Mother Country are in general request throughout the Colonies. In Canada, for example, although British qualifications are recognised, the supply of teachers trained within the Dominion is generally ample for the vacancies that arise. In Alberta and Manitoba, however, there is a brisk demand for competent teachers from this country. And there are several other Colonies in which a demand for educational volunteers from home occasionally arises, New Zealand and West Australia being instances in point. New South Wales and South Australia have openings for male assistants, but have an adequate supply of women teachers. In the South African provinces the dearth of qualified teachers occasions a need for outside applicants.

Prospective emigrants should remember that the lack of local teachers often arises, at least in part, from the scanty remuneration offered by Colonial school authorities, and that the value of a salary is determined not by its amount but by its purchasing power. In the Transvaal, for instance, male assistants receive from £150 to £400 a year, and women £120 to £180; while for principals the range of salaries is £370 to £620, and £260 to £430, respectively. But prices there are about double those in the United Kingdom. In Cape Town, where money goes farther, the average earnings of principals in elementary schools are only £220 a year, and of assistants, £74. Further details as to the prospects of Colonial teaching will be found in the invaluable "Professional Handbook." [See page 2976.]

South African Appointments. Vacancies for science teachers and for instructors in special subjects, such as gymnastics or cookery, are occasionally advertised in the English educational papers. In such cases a second-class passage to the Province is usually provided gratis, the selected applicant, in return, entering into an engagement for three or five years' service. The remuneration is fairly liberal: fully certificated women teachers of cookery, hygiene, or physical drill receive £130 to £180 a year, and the rates for male technical teachers are about double.

In the absence of an agreement of this character, trained teachers in quest of employment in the Cape of Good Hope are recommended by the Emigrants' Information Office to arrange, if possible, for a friend in the Province to apply on their behalf for any suitable vacancy that is advertised out there. They should also address a written application for an engagement to the Secretary, Education Office, Cape Town. And if a candidate sends a statement of his or her qualifications and experience to the Department of Public Education at Cape Town, it will be inserted in the "Education Gazette"—an official organ circulating among school managers and principals. British qualifications, it should be added, are recognised in the Province. Teachers

in the western districts are generally required to be able to speak both Dutch and English.

In the case of female teachers—and these form the majority of the educational staff at the Cape—application for employment may usefully be addressed to the Education Secretary, South African Colonisation Society, 23, Army and Navy Mansions, Victoria Street, London, S.W. Among women, the greatest demand is for efficient teachers of English and of instrumental music. Those who desire to complete their training in the Colony as elementary, secondary, or kindergarten mistresses can obtain from the same Society particulars of the Training College for Women Teachers at Grahamstown, which is open under certain conditions to candidates from home.

Alike in the Cape, the Transvaal, and the Orange Free State, the supply of trained teachers is still inadequate to the demand, and there are therefore good openings for qualified candidates. But women teachers, especially if uncertificated, should not go out to either Province on the chance of securing an engagement unless they have friends with whom they can reside while seeking employment. They are recommended instead to seek the aid of the officials of the Emigrants' Information Office, on whose advice they may rely implicitly.

Teaching Posts Elsewhere. Degrees and training certificates obtained in the United Kingdom are accepted in Western Australia, where there are many openings for teachers. But the chief cause of this demand is the low salaries offered, which fail to attract qualified officers. In view of the high cost of living, the maximum of £240 for assistant masters, and £220 for their feminine colleagues, is admittedly very inadequate.

In New Zealand, although the average of salaries is no higher, the expenses of living are far less, and there is consequently a good local supply of candidates. But well-certificated British teachers are in request; and those who can await the occurrence of suitable vacancies may find excellent openings from time to time in the public schools of the islands. Recently, for instance, £200 a year, and half the cost of the passage out, was offered for a competent instructor in wood-carving and metal-work from this country, the post being a part-time one only.

Teaching certificates obtained in Great Britain are generally recognised in Canada when endorsed by the Minister of Education for the Province. In Ontario, however, the profession is practically closed to all except locally trained candidates. In several of the Provinces the practice prevails of classifying teaching certificates according to the holders' proficiency. As a teacher's salary depends on the class to which he is admitted, candidates are recommended to ascertain from the Education Department, before going out, the standing to which their British qualifications would entitle them.

Public Nursing. The official handbook for emigrants contains a paragraph on nursing in the Colonies which, though not restricted to municipal nursing, summarises so justly the prospects afforded by that particular service that it merits quotation.

"There are occasionally openings in the Colonies for a few trained hospital nurses. There are Homes for providing trained nurses in some Colonial towns, but, as a rule, the over-seas Dominions do not offer any great attraction to nurses; the openings are not very numerous, and the pay is small as compared with that of other callings." It must also be remembered that nurses are now trained to a great extent in the Dominions themselves, and that nurses without proper certificates will generally find it difficult to get situations.

In nearly all British dependencies of every sort, nurses who have been trained in the hospitals of the Motherland are readily admitted to practise, and have at least equal chances with locally trained rivals in competing for appointments in the asylums and hospitals of the colony. Such positions, however, are not often advertised in this country, and are generally secured by candidates who are on the spot.

The nursing services of the Australian continent are largely controlled by the Australasian Trained Nurses' Association—a body which, although it has no legal status, is recognised by the Governments of the several Colonies. It is established in New South Wales, Queensland, South Australia, Western Australia, and Tasmania, and has agreements with a similar body in Victoria and with the New Zealand Hospitals Department. Nurses holding certificates from recognised training schools with a three years' course in Great Britain are eligible to be registered with this Association, and throughout the continent preference is generally given to candidates so registered when making appointments to hospitals. The salaries paid vary according to local demand and other conditions that prevail.

Trained nurses employed in the public service in the New South Wales hospitals receive from £70 to £110 a year, with board and lodging. In Western Australia the rates of pay are £36 to £100 for nurses, and £96 to £156 for matrons, with food and quarters; the highest figures, however, are given only on the goldfields, where all the necessaries of life are dear.

In the municipal and Government hospitals of South Africa the remuneration is also generally high. Trained nurses receive from £60 to £100 a year, and matrons £100 to £200, in some instances with free quarters and washing. There is no opening for women who are not fully trained. British hospital nurses in quest of appointments under the Rhodesian Administration should apply for terms to the London office, 2, London Wall Buildings, E.C. Applications for an engagement should be addressed to the Medical Director at Salisbury, Rhodesia, enclosing duly certified copies of certificates and testimonials.

Asylum Staffs. Nurses in lunatic asylums in Australia are paid from £35 to £80 a year, with free quarters and rations, and matrons generally between £120 and £180, with

similar emoluments. The rates for asylum warders in the Commonwealth vary considerably in the several States, the highest pay being in Western Australia (£90 to £150, with quarters and rations), and the lowest in Tasmania (£65 to £115, with a like allowance). Candidates for posts as nurses or warders in Victoria must be between 21 and 41 years of age.

In South Africa the remuneration of asylum officers, in addition to full or partial allowances, ranges within the following limits: Nurses, £48 to £90; matrons, £90 to £150; and warders, £84 to £120. Salaries are generally lower in the asylums of Cape Colony than in those of the other South African territories.

The Colonial Nursing Association. Although in strictness a private and voluntary movement, this Association has now been accorded a semi-official footing by the action of the Colonial Office in employing it as the chief source from which nurses are drawn for Government service in the Crown Colonies. Apart from its most useful efforts in the direction of private nursing, the Association is thus in the position of an agency for State employment, and as such should be mentioned in our columns. The trained nurses furnished by this organisation to the Colonial Government are employed chiefly in British West and Central Africa, Ceylon, Hong Kong, the Malay States, the Straits Settlements, and the West Indies. The term of service is usually three years. The Association guarantees a fixed salary and allowances, with a free passage home on the satisfactory completion of that term; and should illness or some other unavoidable cause prevent a nurse from carrying out her contract, she is sure of receiving every consideration from the Committee. Nurses seeking an engagement of this nature should apply to the Hon. Sec. of the Association, Hon. Victoria A. Hicks Beach, at the Imperial Institute, London, S.W.

Engineering and Surveying Posts. The prospects of British engineering experts outside their own land are considered in the course on Civil Engineering, and it is necessary to add but a few words on the municipal side of their profession—which is generally less remunerative, by the way, than private practice.

Colonial engagements as municipal engineer or surveyor are not often available to candidates in this country. The exceptions occur when, a very responsible position having to be filled—such as the chief surveyorship of a growing city—there is a dearth of local candidates of the requisite experience. Vacancies of this class are announced in the English engineering journals as they arise. Minor appointments are usually made from among applicants in the colony.

British qualifications, however, are widely recognised, the M.Inst.C.E., in particular, being as valuable in the Colonies as in this country. In Victoria, corporate members of that Institute are eligible under certain conditions for appointment as municipal surveyors, and as such may undertake the construction of roads and bridges for the local authorities. On the other hand, the Lands Survey branch of the State service is recruited mainly by surveyors trained in the department itself.

Apart from professional posts in technical colleges, the Colonial municipalities afford but few openings for chemists. The most important corresponds with the position of public analyst in an English borough. In the Canadian Dominion such officers are required to pass an examination in chemistry and microscopy. In many other parts of the Empire, however, the detection of adulterated food supplies has not become a pressing matter, and thus the field for local Government analysts is still very restricted.

Other Offices. Other vacancies for municipal officers of various grades in the Colonies are announced from time to time in the English Press—generally on terms sufficiently high to attract fully competent candidates. Thus, for the positions of treasurer and assistant treasurer to a leading South African corporation, the respective salaries of £1500 and £600 have been offered. Recently an English medical man, thirty-five years of age, holding the Diploma of Public Health, was appointed Assistant Medical Officer of Johannesburg at £800 a year. For the post of foreman at the Lagos Waterworks a salary of £300, rising to £350, with free passage and free quarters, is on offer as these words are penned. Some few years ago the captain of an English fire-brigade, receiving only £130 a year, obtained the control of a similar force in South Africa at a salary of £600, with free quarters. This post had been advertised in the "Municipal Journal," and was secured by no other means than high testimonials and an excellent record for smartness.

But there is no royal road to such advancement. Suitable vacancies are rare and eagerly contested; and there may be long waiting and many disappointments to endure ere the aspirant ultimately attains success.

A Last Word. In concluding with the present article our survey of the Imperial section, we complete also that greater subject of the Civil Service of which this forms part. As we have sought to show, the Civil Service of the Empire is of unmatched variety and extent, affording scope in one or other of its three divisions—Municipal, National, and Imperial—for the most diverse talents and ambitions; and the liberal, though not extravagant, rewards of each section are available, without let or hindrance, to men of the requisite abilities. We may perhaps be forgiven for emphasising anew, in conclusion, the qualities that make for success. They are, firstly, a sound training; and, lastly, strenuous and thorough work. In the Civil Service, as elsewhere, there are some incompetents and many mediocrities, but the men who win the prizes are they whose keynote is Efficiency.

ERNEST A. CARR

CIVIL SERVICE CONCLUDED

A Course in Banking begins in the Next Chapter in this Group

Differences Between Qualities that are Genetically Inherited and Qualities that are Nurturally Acquired

SOME ASPECTS OF HEREDITY

We have reached the important conclusion that what may be called the normal genetic process, often Mendelian in type, is capable of modification by various conditions that may act upon the germ-cells. Physical factors, such as visible light or invisible radiations, may act upon the germ-plasm within the parental organism, and directly modify the process of gametogenesis. Chemical factors, circulating in the parental blood, may similarly modify gametogenesis—wholly apart from any influence upon the parent, or any so-called "transmission of acquired characters."

Thus recent American observers have noted the occurrence of a higher proportion of epileptics and other defectives than the law of Mendel would allow, in cases where the genetic process has been complicated by parental alcoholism. And, in an inquiry made by the American botanist Macdougal, the direct action of certain chemicals, introduced in the ovaries of plants, caused the production of offspring with an altered type of leaves, some of these alterations following Mendel's law in subsequent generations. It is the neglect of these facts by the observer who has confined himself to pure genetics that has led Professor Bateson to take up the untenable position that no external agency can affect the germ-plasm or the course of Mendelian factors.

Unconstructive Experiment. But it must be recognised that the influences which have been experimentally demonstrated to act upon the genetic process from without are *in no case constructive.* On the contrary, all the influences which we have been able to detect are either indifferent, destructive, or degenerative. We can demonstrate that lead, alcohol, and other agencies, which the present writer has called by the now common name of *racial poisons*, affect the genetic process. The brain of the offspring may thus be damaged. But we have no word of any agency which, acting upon a simian parent, let us say, will cause its offspring to develop a human brain. Hence the problem of organic evolution remains *untouched* by these observations, except that they throw some light on degeneration. The mighty ultimate question is unanswered—How has life ascended?

The process of racial poisoning may be described in a technical term first used by Professor Forel, the great Swiss authority. He calls it *blastophthoria,* and by this term we mean the action of injurious agents upon germ-cell formation. It must not be applied to any of the processes which we are about to describe. And the tragedy of this subject, both for practice and for theory, is that, while we can demonstrate blastophthoria, we have no word of the opposite process. But that is only another way of saying that death is easier to explain than life.

Constructive Experiment Needed. The theory of organic evolution meanwhile awaits experiments whereby the action of special agents upon or in the parent, whether chemical or physical, shall be shown to cause the production of positive, progressive, new characteristics in the offspring. It is impossible to believe that such may not be the case, but hitherto we know only how to destroy. At this hour science has no word of any vital construction, any "creative evolution," by mechanical or physico-chemical means. So much the stronger, evidently, is the case for modern vitalism.

We pass now to the recognition of another process of the highest practical importance, the results of which simulate heredity, and are constantly described as such. No such confusion can well occur in the study of the lower forms of life, though even there instances may be found.

Simulated Heredity. Perhaps the most striking and famous is the disease of silkworms which is known as *pébrine*, and which was elucidated by Pasteur in 1865, to the salvation of the silk industry of France. He found that this disease is due to an infection of the worms by a parasite, which is unfortunately capable of transferring itself from the female worm to her eggs, from which diseased—that is, infected—worms accordingly develop. This looks like hereditary disease, but it is nothing of the sort. It is not what the theorists asserted, until Pasteur arrived—"degeneration of the race of silkworms"—but is a process of infection from parent to offspring at an early stage in the offspring's history.

If such confusion be possible in such a case, how much more so may it occur among the Mammalia, such as ourselves, where the offspring spends many susceptible months of its life within the maternal body? There it is evidently subject to a host of influences, normal and possibly morbid, which are by no means heredity, but are, in fact, influences of nurture or malnutrition. But the offspring, at birth, already displays the consequences of such influences; and if we assume, as most people do, that whatever appears at birth is hereditary, we shall certainly fall into the gravest errors.

A Warning About Terms. In order to avoid them, it is well to look to our vocabulary, which should be purged altogether of a certain word in common and uncritical employment, especially in medical writings. This is the thoroughly misleading, indeterminate, and useless word "congenital," to which no examined meaning ever attaches. The word is commonly used as the equivalent of innate, inherent, inborn, or germinal. Nothing is truly germinal but what was present in the germ. But we persist in attaching quite undeserved importance to the *birth* of those animals which are brought

forth "alive"—as if a bird's egg were not alive. Hence we speak of any character present at birth as 'congenital,' and then we assume that congenital means *genetic*.

In ordinary discussion, in medical literature, and even in what should be the most expert and exact eugenic writings, this distinction is wholly ignored. But it is vital, for the genetic is transmissible, and the mere somatic acquirement, apart from the racial poisons, is not. Consider how eugenics may be thus misled.

Differences Between Acquired and Inherited Features. The word "congenital" is equally foolish and useless in an opposite direction. It leads those who use it to suppose that the genetic characters of an individual are those which appear at birth, and that thus any characters later displayed are acquired. But a man may display for the first time at the age of twenty or sixty a character which is as truly genetic as his nose or his spine—perhaps a beard, perhaps a trait of mind, perhaps a disease. This was not congenital, and yet it is genetic. Thus, to sum up, a character may be "congenital," and yet not inherent but acquired; a character may be not congenital, and yet inherent. Now, the all-important question as regards heredity is not the date in the individual history at which a character appears—as, for instance, before or after birth—but whether the character is genetic, and therefore will be represented in future germ-cells, or merely somatic, and of no racial significance. The case, therefore, is clear that the word "congenital" should be expunged from the vocabulary of science.

Ante-Natal Influences. The responsible biologist knows that nurture begins its influence at conception, and that ante-natal nurture must be reckoned with. The so-called results of heredity can never be passed as such until its reckoning has been made. For many years past, Dr. J. W. Ballantyne, of Edinburgh, author of the classical volumes on "Ante-Natal Pathology," has been calling the attention of the medical profession to the importance of the ante-natal period, in its influence upon the characters of the offspring, among ourselves, as necessarily among all the Mammalia. But even he could not have anticipated the most recent results of observation. Until the last three years and less, the evidence has seemed perfectly clear that countless cases of deaf-mutism, mental deficiency, and epilepsy were really genetic or hereditary, as they seemed to be because they were clearly "congenital." The application of the Wassermann test for the presence within the body of the parasite of syphilis, first by Dr. Kerr Love, of Glasgow, in the study of deaf-mutism, and later by many others in the study of other morbid conditions of the nervous system, has proved that, in an almost incredible number of cases, what we have called heredity is none other than ante-natal infection by syphilis.

Infection not Heredity. The whole practice of eugenics, as we shall later see, must either adapt itself to these discoveries or be repudiated by all responsible people. The remedy for "hereditary degeneracy" may be the segregation of the degenerate, or even the performance of an operation upon him; but if and when "hereditary degeneracy" among ourselves turns out to be exactly what Pasteur proved the so-called "hereditary degeneracy" of silkworms to be, the result of infection of the offspring from the parent, the remedy is to prevent that infection—a very different thing.

Those who have no sense of languages may, if they please, continue to talk of "hereditary syphilis" and "congenital syphilis," and drag in heredity in that way; but, as Dr. Ballantyne has said, it is "an insult to heredity" to use the term in such a connection at all. Hereditary disease, such as hæmophilia and colour-blindness, does exist, as we shall later see, but it is an utterly different thing, being as genetic in origin as any character of the individual.

Pseudo-Heredity. It must already be evident to the reader that exact biological ideas, and exact use of language to represent them, are essential, now that national and social practice is being based, as it should, upon biological truths. But we must state the laws of life with all legal precision if they are to guide us. There is still an even more striking instance of what we have here called pseudo-heredity than any as yet cited.

We speak of persons being "born blind," and describe their condition as "congenital." Such persons constitute from one-third to one-half of the population of our institutions for the blind, but they were not born blind at all. They were born seeing, but at the moment when their eyes, during birth, were first opened to the light they were infected by a parasite called the *gonococcus*, which was already victimising the maternal organism. This is no more hereditary, nor "congenital," nor being "born blind" than if the nurse or doctor were infected, as may happen, from the same source; and such cases will never be prevented, as they can be, until we think honestly and accurately about them.

There is yet another grave consequence of inaccurate thinking about pseudo-heredity. The recent campaign for the protection of infancy has greatly lowered the infantile mortality that occurs during the second half of the first year of life. The mortality in the first half, and especially the first quarter, remains little affected. Hence it has been argued that these infants are "unfit," on account of inferior heredity, and, in fact, are "better dead," and that to attempt to interfere with their mortality is to arrest the beneficent action of "natural selection," and to effect racial degeneracy. Recent attempts have actually been made, on statistical grounds, to show that this is so, and that, in Professor Karl Pearson's words, "Darwinism does apply, and very intensely applies, even to man under civilised conditions." This author concludes that "a heavy death-rate does mean the elimination of the weaklings," and that, "for a constant environment, the higher the infantile death-rate, the more resistant will be the surviving child population." Dr. Newsholme has shown that even the existing figures are in direct contradiction of

these assertions, but, no matter what the existing figures were, they could never prove what is asserted. The truth is that such terms as "Darwinism," and "natural selection," have no place in this connection until the *factor of nurture* is allowed for, and that is the all-important factor which those neglect who report upon these matters without biological knowledge. The elementary fact that the infant has been alive for nine months before its birth is forgotten; and its conditions at birth and the consequences thereof are tacitly and inexcusably assumed to depend upon heredity alone, though it may have been dosed with lead or alcohol, or infected with parasites in any degree.

The Far-flung Influence of Nurture. Yet further, let us learn from the most recent of experimental inquiries how Life bears the record of the past from generation to generation. Even the nurture of the infant affects its remote offspring. The infants of today are the parents of the future. Neo-Darwinism, as we have seen, would have us believe that nothing which we do to individuals can affect the germ-cells within them. But, in fact, the malnutrition of the unborn child and the infant involves the malnutrition of the germ-plasm which they contain, and from which the future will spring.

In the case of many animals and plants we now know how great the consequences of nurture at this time are for the race as well as the individual. The recent work of Professor Stockard, of Cornell University, New York, has shown the potent effect of parental alcoholism upon the nervous system of the offspring in guinea-pigs; but, in a private letter to the present writer, he states that further experiments, which he hopes to publish before the end of the present year, show the influence upon the third generation to be often much more marked than upon the second. This result seems at first to be anomalous and absurd, but it clearly means what is indeed probable—that the influence of the poison, entering the unborn body of the fœtal guinea-pigs from the blood of the mother, is less marked upon the developing body-tissues than upon the developing germ-plasm, and hence upon the grandchildren of the alcoholic guinea-pig. On such grounds as these it must be evident that the nurture of infancy, including its ante-natal nurture, is also the nurture of the race, and therefore an essential part of true eugenics.

Normal Heredity. We are now in a position to classify and distinguish the various modes of action which may complicate or simulate the genetic process, and may also briefly note the main facts, still very sparse, which have been hitherto defined. We begin with a clear idea of the normal hereditary or genetic process. That process may not be always Mendelian; indeed, there arises no question of Mendelism at all in those cases where reproduction is asexual, or those in which the ova may develop without fertilisation by spermatozoa—as in the parthenogenetic production of drones from the unfertilised eggs of the bee.

Nevertheless, it is Mendelian inquiry that has taught us how to conceive of the genetic process, whether sexual or asexual, as essentially dependent upon the presence of certain definite factors in the germ-cells. Normally, under standard conditions of nurture, we suppose these factors to go their constant way, and have their constant consequences, from generation to generation. That is normal heredity.

Experiments on Indifference. Next we look for influences that may modify germ-cells and the factors they contain, after the fashion in which ultra-violet light modifies anthrax bacilli. When we speak of the modification of germ-cells we really mean the modification of gametogenesis, the process by which germ-cells are made. In expectation, we should find influences which modify gametogenesis in any of three ways. Some will change the type of gametes, and hence of the next generation, indifferently, as in Macdougal's observations, where the offspring were neither higher nor lower in type than the parents, in consequence of the chemicals he introduced, but were simply altered, as in the form of their leaves. Similarly, the cocci descended from anthrax bacilli exposed to ultra-violet light were simply altered, neither higher nor lower in type.

Failure in Betterment. Second, we should expect to find influences which alter the gamogenetic process for the better, so that the germ-cells are higher in type than they were, progressive or creative evolution being the result. Such influences, applied to human beings of low type and poor ancestry, would raise the quality of their subsequent children, effecting what the writer calls constructive eugenics. Similarly, the offspring of plants or animals would be raised in type by such influences acting on the parents. As we have seen, no record exists of any such action.

Experimental science is an absolute blank in this respect. True, it is the general popular belief that education of the future parent, in music, or language, or good manners, or anything else, will favourably and correspondingly affect the offspring, but there exists as yet no vestige of scientific evidence in favour of this view, and there is an infinite mass of evidence to the contrary. There is no more universal belief, and none can be more reasonable, apparently, than that the racial type can be raised directly by favourably influencing future parents, and the mode of doing so may yet be discovered. But we know nothing yet of any influence that raises the type of the germ-cells that any organism, of any species, animal or vegetable, may bear. It is worth while to insist upon this fact, as we are doing, for its incalculable significance and consequences.

Signs of Damage. But it is easy to destroy, or to damage, and we have abundant evidence of racial poisons that injure gametogenesis, so that damaged germ-cells, and hence damaged individuals, result. Here we have influences striking sideways from without at the normal course of the genetic process, and it seems useful that we should sum up all such facts under the heading of Morbid Heredity,

which is here proposed for them. We are certainly discussing "heredity" here, for whatever alters germ-cells is of the very essence of that subject; but all such influences that we know, with a few indifferent exceptions, are injurious, and they are evidently accidents, vicious, abnormal influences which should not exist, and the results of which are pathological. Morbid Heredity seems, therefore, to be the term which best describes this *addendum* to the study of the normal genetic process.

Facts of Morbid Heredity. Its main facts appear to be as follow. The vast majority of morbid or abnormal influences, acting upon and manifesting themselves in the individual organism, do not produce morbid heredity. We already know why—they do not touch the germ-plasm. Against the various poisons which are inevitably produced within the body, in the course of digestion, as a result of muscular exertion, and so forth, the germ-plasm seems to be protected. Such poisons are mostly colloids, and do not reach it. In order to effect blastophthoria, a poison must apparently be a crystalloid, and especially one which is not a natural inhabitant of the body.

Such a description answers to the most important and most exactly studied of the chemical racial poisons in the case of ourselves and several other mammals. Those poisons are alcohol and lead. Either of these may act upon either parent, but it is evident that blastophthoria cannot be asserted except in cases where the male parent is poisoned. If the mother be affected, the influence upon the offspring may be due to ante-natal malnutrition, as we shall see. Even if the mother were poisoned before conception occurred, her lowered health would react upon the ante-natal nurture of the offspring, and we could not *prove* the occurrence of blastophthoria in such a case. The father alone offers a crucial instance. If he alone be poisoned, and the offspring are degenerate, we know that blastophthoria occurred.

Checks on Experiment. Such observations of experiments need careful checking. The stock must be healthy, and we must have record of three generations in all—or we may be deceived by choosing an impure dominant, who carries recessive defect in half his germ-cells. But in man and in various species of the lower animals we now have proof of blastophthoria, in the case both of lead and of alcohol.

Sir Thomas Oliver, of Newcastle, has made the experiments dealing with lead, and Professor Stockard, already mentioned, the most recent of those dealing with alcohol. In the case of alcohol, we also have microscopic evidence, thanks to the seven years' work of the Swiss pupil of Professor Forel, Dr. Bertholet, who has demonstrated the degeneration of the essential cells, both of the male and the female reproductive glands, in mankind, under the influence of chronic alcoholism. It will be an extremely important task, highly profitable for mankind, for the future to ascertain what other racial poisons there may be.

Luxury and Degeneration. Recently, in Paris, Professor Houssay, of the Sorbonne, has shown that the feeding of fowls on an exclusive meat diet causes racial degeneracy. In Edinburgh, Dr. Chalmers Watson has shown that feeding rats on meat in large quantities causes degeneration of the ovaries, microscopically demonstrable, and not at all dissimilar to that demonstrated by Bertholet in a parallel case. If modes of diet are capable of producing such consequences, the sooner they are known the better. Sheer luxury, we see, may lead to direct effects upon the germ-plasm, and may warrant all or much that the moralists and historians have alleged against it as the cause of national decadence.

Pseudo-Heredity Through Lead and Alcohol. So much for morbid heredity, as we have called it. Finally, we note, and must never forget, the existence of pseudo-heredity, which is, in fact, none other than the result of ante-natal malnutrition, intoxication, or infection—which involves malnutrition and intoxication. We have previously noted that the nutritive relation of the germ-plasm to the individual body is not dissimilar to that of the embryo or fœtus to its mother. Hence we note that, just as lead and alcohol may cause blastophthoria, so they may cause ante-natal malnutrition, the results of which may be very similar. This, however, is not heredity, any more than if the child were poisoned after birth. Both in the case of lead and that of alcohol, the poison has been demonstrated within the child at birth. But hosts of other poisons, colloidal in chemical type, may circulate in the mother's blood, and never cross over to the fœtal circulation, thanks to the action of what Dr. Ballantyne calls the "placental filter"—the placenta, or "after-birth," being the characteristic mammalian organ in which the circulatory systems of mother and child come into close apposition, for interchange of certain contents of the blood, though there is no direct continuity between them. It is obvious that the results of malnutrition, due to the passage of lead, for instance, from one system to the other, are not heredity.

The Abolition of Bad Heredity. Vastly more serious, in cases in which it occurs, is the passage of parasites from one organism to the other, as in *pébrine.* The parasite of rheumatic fever should also be noted, as it is responsible for most cases of what is called "congenital heart disease." It will be obvious to the reader that the clear appreciation of pseudo-heredity and its importance lends the utmost weight to the eugenic demand for the right care of expectant motherhood. No better instance could be cited for the proposition that sound biology leads to sound social and political practice. It will be well if, instead of continuing, in the face of these facts, to talk of the multiplication of degenerates, we begin to end those infective and toxic processes of which so-called bad heredity is most often the consequence.

C. W. SALEEBY

Extraordinary General Meetings. Increasing and Reducing Capital. Winding Up a Public Company. Powers of Liquidators and Directors.

THE WORKING OF A COMPANY

In addition to the matters already dealt with, there is a great deal of other information which the secretary of a limited liability company should have at his fingers' ends if he is to do his work efficiently and be independent of solicitors, so far as the routine business of the company is concerned. Many things, for instance, have to be filed at Somerset House, and if this is not done there is a liability to heavy fines. There is no difficulty, for it is quite easy for a secretary to get one of the many manuals that are now published, setting forth in detail the rules and regulations with which he has to conform; and the officials at Somerset House are always ready to give any information that may be required as to the routine of filing and stamping.

Ordinary and Extraordinary Meetings. Any business outside ordinary business carried by ordinary resolution at an ordinary or annual general meeting is regarded as special or extraordinary business and needs a special or extraordinary resolution. Ordinary business is defined by Table A of the Companies Act, 1908, as "sanctioning a dividend, the consideration of the accounts, balance-sheets, and the ordinary report of the directors and auditors, the election of directors and other officers in the place of those retiring by rotation, and the fixing of the remuneration of the auditors." Ordinary business may, however, be transacted at an extraordinary meeting; and as the Companies Act provides for but one ordinary general meeting a year, and many companies balance their books twice a year, it is quite customary for the directors to call an extraordinary meeting partly for the transaction of ordinary business such as that described above.

Extraordinary and Special Resolutions. For certain matters, such as the increase of the share capital, the voluntary winding up of the company, the delegation of powers to creditors, arrangement with creditors, sanctioning a scheme of liquidation, disposing of books in dissolution, the altering of the value of certain classes of shares, an extraordinary resolution is required; while for other matters, such as changing the name of the company, extending the objects clause of the memorandum of association, subdividing the shares of the company, reducing the capital, rendering unlimited the liability of directors, giving power to return accumulated profits in reduction of paid-up share capital, appointing inspectors to inquire into the affairs of the company, converting a private into a public company, adding to or altering the articles of association, and so on, a special resolution is required. According to the Companies Act (1908) a resolution is an extraordinary resolution when it has been passed by a majority of not less than three-fourths of such members entitled to vote as are present in person or by proxy (where proxies are allowed) at a general meeting, of which notice, specifying the intention to propose the resolution as an extraordinary resolution, has been duly given; and a resolution is a special resolution when it has been passed in the manner required for the passing of an extraordinary resolution, and confirmed by a majority of such members entitled to vote as are present in person or by proxy at a subsequent general meeting, of which notice has been duly given, and held, after an interval of not less than fourteen days or more than one month, from the date of the earlier meeting.

Convening an Extraordinary General Meeting. The extraordinary general meeting for such purposes as have been mentioned above is convened by the directors, but the Act allows an extraordinary meeting to be convened by shareholders. The clause in the Act which gives this right to shareholders declares that, notwithstanding anything in the articles of a company, the directors shall, on the requisition of the holders of not less than one-tenth of the issued share capital of the company upon which all calls or other sums then due have been paid, forthwith proceed to convene an extraordinary general meeting. The requisition must state the objects of the meeting, and must be signed by the requisitionists and deposited at the registered office of the company, and may consist of several documents in like form, each signed by one or more requisitionists. If the directors do not proceed to cause a meeting to be held within twenty-one days from the date of the requisition being so deposited, the requisitionists, or a majority of them in value, may themselves convene the meeting, but any meeting so convened shall not be held after three months from the date of the deposit. If at any such meeting a resolution requiring confirmation at another meeting is passed, the directors shall forthwith convene a further extraordinary general meeting for the purpose of considering the resolution, and, if thought fit, of confirming it as a special resolution. If the directors do not convene the meeting within seven days from the date of the passing of the first resolution, the requisitionists, or a majority of them in value, may themselves convene the meeting. Any meeting convened under this section of the Act by the requisitionists has to be convened in the same way, as nearly as possible, as that in which meetings are convened by directors.

The directors may call an extraordinary general meeting at any time they think fit, but at such meetings only the special business for which they have been convened can be dealt

with, and any special resolution which has been passed at one meeting and needs confirmation at a second must be confirmed in exactly the same terms as those in which it was originally passed, otherwise it must be rejected, as no alteration or modification is allowed. The same rules as to a quorum which apply to the ordinary general meeting apply also to an extraordinary meeting, and any member present may move, without notice, that the meeting be adjourned. Such a resolution takes precedence of other matters in hand; and if it is seconded and carried when put to the meeting, then another resolution is needed fixing the time and place for the adjourned meeting. No new business may be introduced or transacted without notice at an adjourned meeting, which must confine itself entirely to the matters left unfinished at the first meeting; but if notice of fresh business has been sent in due form to the shareholders, then, of course, it can be legally transacted at the adjourned meeting when that is held.

Notice of an Extraordinary General Meeting. The rule that at least seven days' notice, exclusive of the day on which the notice is served, but inclusive of the day for which the notice is given, must be sent to all members of the company for an ordinary general meeting applies equally to an extraordinary meeting. If a member has no registered address in the United Kingdom, and has not supplied such an address for the giving of notices to him, a notice addressed to him and advertised in a newspaper circulating in the neighbourhood of the registered office of the company is deemed to be duly given to him on the day on which the advertisement appears. A notice may be given by the company to the joint holders of a share by giving notice to the joint holder named first in the register in respect of the share. A notice may be given to the persons entitled to a share in consequence of the death or bankruptcy of a member by sending it through the post in a prepaid letter addressed to them by name, or by the title of representatives of the deceased, or trustee of the bankrupt, or by any like description, at the address in the United Kingdom supplied for the purpose by the persons claiming to be so entitled, or, until such an address has been so supplied, by giving the notice in any manner in which the same might have been given if the death or bankruptcy had not occurred. These matters have been given at some detail because the Companies Act is very emphatic in insisting that notice of every general meeting, whether ordinary or extraordinary, must be given in some manner authorised in Table A, "to every member of the company (including bearers of share warrants) except those members who, having no registered address within the United Kingdom, have not supplied to the company an address within the United Kingdom for the giving of notices to them; and also to every person entitled to a share in consequence of the death or bankruptcy of a member, who, but for his death or bankruptcy would be entitled to receive notice of the meeting." No other persons are entitled to receive notices of general meetings.

The Wording of the Notices. While there is no actual hard-and-fast phraseology legally appointed for the notice convening an extraordinary general meeting, there is a more or less stereotyped form that is pretty closely followed, which meets the legal requirements. At the head of the sheet is printed the full registered name of the company, with the notice following and the resolution to be submitted. The notice would read like this: "The Mid-China Development Company, Limited, 801, Cheapside, London, E.C. Notice is hereby given that an extraordinary general meeting of the above-named company will be held at the registered offices of the company, 801, Cheapside, London, E.C., on Thursday, the 6th day of August, 1914, at three o'clock in the afternoon, for the purpose of considering the following resolution:

"'That the name of the company be changed to the Mid-China and General Trading Company, Limited.'

"If the above resolution is passed by the necessary majority, it will bs submitted for confirmation as a special resolution at a second extraordinary general meeting to be subsequently convened.—Dated the 28th day of July, 1914. By order of the Board, JOHN SMITH, Secretary."

The notice for the subsequent meeting to confirm the resolution would have the name and address of the company at the head as before, and the wording of the notice would be as follows:

"Notice is hereby given that an extraordinary general meeting of the above-named company will be held at the registered offices of the company, 801, Cheapside, London, E.C., on Monday, the 24th day of August, 1914, for the purpose of confirming the following resolution, which was passed at the extraordinary general meeting held on Thursday, the 6th of August, 1914:

"'That the name of the company be changed to the Mid-China and General Trading Company, Limited.'

"Dated this 16th day of August, 1914. By order of the Board, JOHN SMITH, Secretary."

Registering Special Resolutions. Within fifteen days from the passing of an extraordinary resolution or the confirmation of a special resolution a printed copy must be forwarded to the Registrar of Companies, so that he may record the same in the files; and where articles have been registered, a copy of every special resolution for the time being in force must be embodied in or annexed to every copy of the articles issued after the confirmation of the resolution. Where articles have not been registered, a copy of every special resolution must be forwarded in print to any member at his request on payment of one shilling, or such less sum as the company may direct. If a company makes default in printing or forwarding a copy of a special or extraordinary resolution to the registrar it is liable to a fine not exceeding two pounds for every day during which the default continues; and if a company makes default in embodying in or annexing to a copy of its articles, or in forwarding in print to a member,

when required, a copy of a special resolution, it is liable to a fine not exceeding one pound for each copy in respect of which default is made. Not only is the company liable, but every director and manager of a company who knowingly and wilfully authorises or permits any default of the kind described is personally liable to a like penalty with the company.

Increasing the Capital. A company whose business is growing often finds that it requires more capital in order that the natural development may not be hampered, and this contingency is provided for in the Companies Act. The company may alter the conditions of its memorandum of association, and may increase its capital by the issue of new shares of any amount it may decide upon. The articles of association will probably have provided for this, and stated whether the necessary resolution is to be ordinary, extraordinary, or special. If there is no definite specification, then under Table A an extraordinary resolution is necessary, and this is the usual means resorted to. Subject to any direction to the contrary that may be given by the resolution sanctioning the increase of share capital, all new shares must, before issue, be offered to such persons as at the date of the offer are entitled to receive notices from the company of general meetings, in proportion, as nearly as the circumstances admit, to the amount of the existing shares to which they are entitled. The offer must be made by notice specifying the number of shares offered, and limiting a time within which the offer, if not accepted, will be deemed to be declined. After the expiration of that time, or on the receipt of an intimation from the person to whom the offer is made that he declines to accept the shares offered, the directors may dispose of the same in such manner as they think most beneficial to the company. The directors may dispose of any new shares beyond the number which have thus to be offered to existing shareholders. The new shares will be subject to the same provisions with reference to the payment of calls, lien, transfer, transmission, forfeiture, and otherwise as the original shares.

Decreasing the Capital. In the same way a company may reduce its capital, but here the restrictions are severe, because of the rights of creditors. The reasons for which a company sometimes desires to decrease its capital are various. It may have lost some of the capital or have insufficient assets to represent it in full, or it may find that its capital is more than can be profitably employed in the business. In order to reduce capital a special resolution has to be passed by the company, after which the words "and reduced" must be added to the name of the company, and remain a part of the name until such time as the court declares otherwise. When the special resolution has been passed, application must be made to the court to sanction the reduction. If the reduction does not involve the diminution of any liability in respect of unpaid capital, or the payment to shareholders of any paid-up capital, creditors are not allowed to make any objection, and, unless the court specially requires it, their consent to the decrease of capital is not necessary. But if the opposite is the case, then all objecting creditors must be paid off or secured in the terms of the Act. The reduction having been sanctioned by the court, a copy of the order must be filed with the registrar, who forwards a certificate to the company as evidence that the terms of the Companies Consolidation Act have been complied with. All share certificates then have to be called in and amended, and the necessary rectifications made in the register of members. If the shares have been reduced in nominal value, this fact is indicated by a notification across the face of the certificate and at the head of each page in the register. Where the preference shares rank first in regard to capital as they do in regard to dividend, then ordinary shares must first be written down in any decrease of the company's capital.

Different Ways of Reducing Capital. There are different ways in which the capital of the company may be decreased. It may be done by extinguishing or reducing the liability on any shares of the company in respect of share capital not paid up; or it may be done by cancelling any paid-up share capital which is lost or unrepresented by available assets, either with or without extinguishing or reducing liability on its shares; or it may be done by paying off any paid-up share capital which is in excess of the wants of the company, either with or without extinguishing or reducing liability on any of its shares; or it may be done by cancelling shares which, at the date of the passing of the resolution in that behalf, have not been taken or agreed to be taken by any person; or, finally, it may be done by returning accumulated profits.

Winding Up a Company. A company may be terminated or brought to an end by three methods: it may be wound up by the court, it may be voluntarily wound up, or it may be wound up voluntarily under the supervision of the court. There are six different circumstances in which the company may be compulsorly wound up by the court—namely, if it has by special resolution resolved that it be wound up by the court; if default is made in filing the statutory report or in holding the statutory meeting; if the company has not begun business within a year from its incorporation, or has suspended business for a whole year; if the number of members is reduced in a private company below two or in a public company below seven; if the company is unable to pay its debts; and, finally, if the court is of opinion that it is just and equitable that the company should be wound up. An application to the court for the winding up of a company must be by petition, presented either by the company or by a creditor or creditors or by a contributor. In the case of a petition for winding up on the ground of default in filing the statutory report or in holding the statutory meeting, only a shareholder may present the petition; and a contingent or prospective creditor who petitions must give security for costs, and make out a *prima facie* case which will satisfy the court.

Powers of a Liquidator. The liquidator in a winding up by the court has power, with the sanction of the court, to take legal proceedings on behalf of the company; to carry on the business of the company so far as may be necessary for its beneficial winding up; to employ a solicitor or other agent, under certain restrictions, to do any business that the liquidator himself is unable to do; to sell the property of the company by public auction or private contract, with power to transfer the whole to any person or company, or to sell the same in parcels; to execute deeds, receipts, and other documents, using, where necessary, the company's seal; to draw, accept, make, and indorse any bill of exchange or promissory note in the name and on behalf of the company; to raise on the security of the assets of the company any money requisite; and to do all such other things as may be necessary for winding up the affairs of the company and distributing its assets. Where a liquidator is provisionally appointed by the court, the court may limit and restrict his powers by the order appointing him.

Voluntary Winding Up. Most companies that come to an end, however, are wound up voluntarily. A company may be wound up voluntarily (1) when the period fixed for the duration of the company by the articles expires, or the event (if any) occurs on the occurrence of which the articles provide that the company is to be dissolved, and the company in general meeting has passed a resolution requiring the company to be wound up voluntarily; (2) if the company resolves by special resolution that it be wound up voluntarily; and (3) if the company resolves by extraordinary resolution to the effect that it cannot by reason of its liabilities continue its business, and that it is advisable to wind up. The method of winding up voluntarily is to call an extraordinary general meeting, the notice for which sets forth the resolutions to be submitted. These are usually two, first: "That the such-and-such company be wound up voluntarily," and secondly: "That Mr. So-and-So, of such an address, be and hereby is appointed liquidator in the said winding up." It is not actually necessary to give notice of the appointment of a liquidator, although this is usually done. The resolution to wind up having been passed at the first meeting and confirmed at the second, has to be advertised in the "London Gazette," and the winding up begins on the day when the resolution authorising it was passed. The controlling power then passes from the directors to the liquidator, and business is only carried on in so far as may be necessary for the beneficial winding up of the company.

Meeting of Creditors. Within twenty-one days after his appointment, the liquidator has to file a notice of the appointment with the Registrar of Companies on a prescribed form, and the penalty for failing to do this is £5 per day for the period during which he is in default. Further, within seven days of his appointment he has to send notice by post to all the creditors of the company, calling a meeting of creditors, to be held after fourteen days and within twenty-one days from the date of his appointment. The notice must state the time and place of meeting, and must be advertised once in the "London Gazette," and at least once in two local newspapers. This meeting of creditors decides whether it will agree to the liquidator appointed, or whether application shall be made to the court for the appointment of another liquidator, either in place of or additional to the first one. It may also decide to appoint a committee of inspection. In deciding such matters the court takes into consideration the interests of the creditors and contributories.

Liability of Past and Present Members. When a company is wound up, all present members have to contribute to the assets of the company to an amount sufficient for the payment of its debts and liabilities, and the costs, charges, and expenses of the winding up. This liability, however, only extends up to the amount, if any, unpaid on their shares. If the existing members are unable to satisfy the contributions required, then past members may be called upon, but a past member is not liable to contribute if he has ceased to be a member for one year or upwards before the beginning of the winding up, and he is not liable to contribute in respect of any debt or liability of the company contracted after he ceased to be a member.

Transferring to Another Company. When a company is being wound up voluntarily, and it is proposed to transfer or sell the whole or part of its business or property to another company, the liquidator may, with the sanction of a special resolution of the company he is winding up, receive, in compensation or part compensation for the transfer or sale, shares, policies, or other like interests in the transferee company, for distribution among the members of the transferor company, or may enter into any other arrangement whereby the members of the transferor company may, in lieu of receiving cash, shares, policies, or other like interests, or in addition thereto, participate in the profits of the transferee company. Any sale or arrangement so made is binding on the members of the transferor company. If any member of the transferor company who did not vote in favour of the special resolution at either of the meetings held for passing and confirming the same expresses his dissent therefrom in writing addressed to the liquidator, and left at the registered office of the company within seven days after the confirmation of the resolution, he may require the liquidator either to abstain from carrying the resolution into effect or to purchase his interest at a price to be determined by agreement or by arbitration. If the liquidator elects to buy the member's interest, the purchase money must be paid before the company is dissolved.

Priority of Debts in a Winding-Up. In a winding up certain claims have priority of all other debts, and these include: (1) All parochial or local rates, and all assessed taxes, land tax, property or income tax. (2) All

wages or salary of any clerk or servant in respect of services rendered to the company during four months before the said date, not exceeding fifty pounds; and all wages of any workman or labourer, not exceeding twenty-five pounds, whether payable for time or for piece-work, in respect of services rendered to the company during two months before the commencement of the winding up. (3) All amounts (not exceeding in any individual case one hundred pounds) due in respect of compensation under the Workmen's Compensation Act, 1906, the liability of which accrued before the said date, unless the company is being wound up voluntarily merely for the purposes of reconstruction or of amalgamation with another company. All these debts rank equally among themselves, and must be paid in full, unless the assets are not sufficient to meet them, in which case they are paid in equivalent proportions as far as the assets go. Such sums as may be required for the costs and expenses of the winding up may, however, be retained by the liquidator. If the winding up continues for more than a year, the liquidator must summon a general meeting of the company at the end of the first year, and present a statement showing what he has done and the present condition of affairs. He must submit accounts, and these accounts have also to be sent to the registrar.

Concluding the Liquidation. When the liquidator has collected all the moneys due to the company and realised all its assets, and when he has satisfied all claims as far as the money would go, he has to make up final accounts, and present these to a final meeting of the company. This meeting must be advertised in the "London Gazette," and at least a month's notice must be given to the shareholders. Within a week after the holding of the meeting the liquidator has to deposit with the registrar a "return of the final winding-up meeting, with the statutory declaration therein." Three months later the registrar strikes the name of the company off the list, and it ceases to exist any longer. There are various reasons for which the registrar may strike a company off the list. He may do so if he has ground for believing that it is not carrying on business. He can only do this, however, after sending two letters to the company at specified intervals and advertising in the "London Gazette" what he proposes to do, without receiving any reply from the company. Even after being struck off, if a company or any member or creditor feels aggrieved, the court, on application, may, if satisfied that the company was at the time of striking off carrying on business or in operation, restore it to the register; and the company will be deemed to have continued in operation as though its name had not been struck off.

Reconstruction of a Company. Sometimes it is considered expedient for various reasons to end a company, and to form another to carry on the business. This is called reconstruction. It is often done where creditors have to be satisfied, and their claims may be settled by giving them shares in the new company. Also, it is done in the case of amalgamations of companies. The first company is wound up in the ordinary way, the secretary, as a general rule, being appointed liquidator. An agreement is then drafted by the company's solicitor for the sale by the liquidator of goodwill, assets, etc., to the new company. The shareholders have, of course, previous to the extraordinary general meeting, been advised of the advantages that will accrue to them through the proposed course. When the final meeting of the old company is held, unless formal permission has been previously given, the liquidator must be authorised to hand over to the new company the old books and accounts.

Filing the Annual Return. Every company must at least once in every year make out a list of all persons who, on the fourteenth day after the first or only ordinary general meeting in the year, are members of the company, and of all persons who have ceased to be members since the date of the last return, or (in the case of the first return) of the incorporation of the company. This list must state the names, addresses, and occupations of all the past and present members mentioned in it, and the number of shares held by each of the existing members at the date of the return, specifying shares transferred since the date of the last return or (in the case of the first return) of the incorporation of the company by persons who are still members and have ceased to be members respectively, and the dates of registration of the transfers. It must also contain a summary distinguishing between shares issued for cash and shares issued as fully or partly paid up otherwise than in cash, and must specify the following particulars:

(1) The amount of the share capital, and the number of shares into which it is divided; (2) the number of shares taken from the beginning of the company up to the date of the return; (3) the amount called up on each share; (4) the total amount of calls received; (5) the total amount of calls unpaid; (6) the total amount of the sums, if any, paid by way of commission in respect of any shares or debentures, or allowed by way of discount in respect of any debentures, since the date of the last return; (7) the total number of shares forfeited; (8) the total amount of shares or stock for which share warrants are outstanding at the date of the return; (9) the total amount of share warrants issued and surrendered respectively since the date of the last return; (10) the number of shares or amount of stock comprised in each share warrant; (11) the names and addresses of the directors; (12) the total amount of debt due from the company in respect of all mortgages and charges which are required to be registered under the Act of 1908. With this summary (except in the case of private companies) must also be filed a balance-sheet, audited by the company's auditors, and containing a summary of its share capital, its liabilities, and its assets, giving such particulars as will disclose the general nature of those liabilities and assets, and how the value of the fixed assets has been

arrived at. This balance-sheet need not, however, include a statement of profit and loss. The list and summary referred to above must be contained in a separate part of the register of members, and must be completed within seven days after the fourteenth day from the annual general meeting. A copy of it, signed by the secretary or manager, must at once be forwarded to the Registrar of Companies. If there is any default in carrying out these provisions, the company is liable to a fine not exceeding £5 for every day during which the default continues; and every director or manager who wilfully authorises or permits such default is personally liable to a similar penalty.

The Registration of Mortgages. All mortgages or charges for the purposes of securing any issue of debentures, on uncalled share capital, on land, on book debts, on the undertaking or property of the company, and any charge created or evidenced by an instrument which, if executed by an individual, would require registration as a bill of sale, will, so far as any security on the company's property or undertaking is conferred, be void against the liquidator and any creditor of the company unless the particulars of the mortgage or charge, together with the instrument, if any, by which it is created or evidenced, are delivered to the Registrar of Companies for registration within twenty-one days after the date of its creation, but without prejudice to any contract or obligation for repayment of the money thereby secured. The registrar has to keep with respect to each company a register in the prescribed form of all the mortgages and charges created by the company, and on payment of the prescribed fee he must enter in the register, with respect to every such mortgage or charge, the date of creation, the amount secured by it, short particulars of the property mortgaged or charged, and the names of the mortgagees. The registrar must give a certificate of the registration of any mortgage or charge thus registered, and this will be conclusive evidence that the requirements of the Act as to registration have been carried out. The register kept in pursuance of these requirements of the Act is open to inspection by any person on payment of a fee not exceeding one shilling for each inspection. Heavy penalties for default in these matters are prescribed. In addition to registration of mortgages and charges with the Registrar of Companies, every limited company must itself keep a register of mortgages and charges, with the amounts, a short description of the property mortgaged and charged, and the names of the mortgagees. Here again there are heavy penalties for default.

Powers and Duties of Directors. The directors are the responsible managers of the company, and every company must keep at its registered office a register containing the names and addresses and occupations of its directors. A copy of these particulars must be sent to the registrar, who must be notified from time to time of any change in the directorate.

The penalty for neglecting to do this is £5 for every day during which the default continues, and not only the company but also the directors are personally liable.

The qualification of a director is the holding of at least one share in the company, and the remuneration of directors is from time to time determined by the company in general meeting. The directors may from time to time appoint one or more of their body to the office of managing director or manager, for such term and at such remuneration as they think fit; and the remuneration may be in the form of salary, commission, participation in profits, or a combination of all or any of these. While the company may in general meeting make regulations concerning the powers of the directors, no regulations made by the company can invalidate any prior act of the directors which would have been valid if that regulation had not been made. The directors must have minutes made in books provided for the purpose of all appointments of officers made by the directors, of the names of the directors present at each meeting of the directors and of any committee of the directors, and of all resolutions and proceedings at all meetings of the company, of the directors, and of committees of the directors. Every director present at a meeting of directors or committee of directors must sign his name in a book to be kept for the purpose.

Disqualification of Director. The office of a director is vacated if the director holds any office of profit under the company except that of managing director or manager, becomes bankrupt, becomes of unsound mind, is concerned in the profits of any contract with the company, or ceases to hold the share or shares which qualify him for the post according to the Act of 1908. No director need vacate his office, however, on account of the fact that he is a member of a company which has entered into contracts with, or done work for, the company of which he is director. He must not, however, vote in respect of such contract or work.

The Rotation of Directors. At the first ordinary meeting of the company the whole of the directors must retire from office, and at the ordinary meeting in every subsequent year one third of the directors for the time being, or the number nearest to one third, must retire. The directors to retire are those who have been longest in office since their last election; but where the directors have been elected on the same day, the ones to retire may be determined by agreement or by lot. A retiring director is eligible for re-election, and the company, at the general meeting at which the director retires, may fill up the vacated office by electing a person to it. If the places of vacating directors are not filled, the meeting must stand adjourned to the same day in the next week at the same time and place; and if at this adjourned meeting the places are not filled, then the vacating directors are considered as re-elected. The company may, of course, in general meeting, increase or reduce the number of directors from time to time. A casual vacancy occurring on the board may be filled by the directors, but the person so chosen must retire at the date that the director whose

place he fills would have retired. By an extraordinary resolution the company may remove a director before the expiration of his period of office, and may by ordinary resolution appoint another person in his stead, but he must retire at the date the removed director would have been retiring in ordinary routine.

Directors' Meetings. As it is really the directors who direct the policy of a limited liability company, it is at their meetings that the lines are laid down that are to guide the management. These meetings in all really live companies are held at regular intervals, once a month or, as in many cases, once a week. It is usual for the secretary to be present, and he takes the minutes of the proceedings, which are far less formal than in the case of the shareholders' meetings, where everything is usually cut and dried. Of course, there is a certain amount of formal business for the directors to carry out in order to fulfil the requirements of the Companies Act, such as the signing and sealing of documents, etc., but when it comes to matters of general management the discussion is, of necessity, free, and not on stereotyped lines.

Where the directors are scattered about the country, it is quite usual for them to appoint a committee of their own number to transact the general business of the company, and even where the whole of the directors are more accessible a committee is very often appointed to meet at more regular intervals than the full body of the directorate. The minutes will, of course, record the names of the directors present and give a fairly detailed narrative of the proceedings. The meetings of the directors are usually held at the registered office of the company in a room called the board-room. According to Table A they " may meet together for the despatch of business, adjourn, and otherwise regulate their meetings as they think fit. Questions arising at any meeting shall be decided by a majority of the votes. In case of an equality of votes the chairman shall have a second or casting vote. A director may, and the secretary on the requisition of a director shall, at any time summon a meeting of the directors. The quorum necessary for the transaction of the business of the directors, and unless so fixed, shall (when the number of directors exceeds three) be three." The Act further declares that "all acts done by any meeting of the directors or of a committee of directors, or by any person acting as a director, shall, notwithstanding that it be afterwards discovered that there was some defect in the appointment of any such directors or persons acting as aforesaid, or that they or any of them were disqualified, be as valid as if every such person had been duly appointed and was qualified to be a director."

Dividends. No dividend may be paid otherwise than out of the profits, and subject to the rights of any persons who own shares with special rights as to dividends. All dividends must be declared and paid according to the amounts paid on the shares, but, according to Table A, where nothing is paid up on any of the shares in the company, dividends may be declared and paid according to the amounts of the shares. No amount paid on a share in advance of calls may, while carrying interest, be treated for dividend purposes as paid on the share. The company in general meeting declares dividends, but no dividend may exceed the amount recommended by the directors, and the directors may, before recommending any dividend, set aside, out of the profits of the company, such sums as they think proper as a reserve, which shall, at the discretion of the directors, be applicable for meeting contingencies or for equalising dividends, or for any other legitimate purpose. Pending the application of such reserve, the money may be employed in the business, or be invested as the directorate think fit. The directors may from time to time pay to the members of a company such interim dividends as they think are justified by the profits. Notice of the closing of the transfer books of a company for a short time for the preparation of dividend warrants is usually advertised, and the warrants are got ready before the meeting, but they must not be sent out till the dividend has been actually sanctioned by the shareholders.

Companies Established Outside the United Kingdom. In conclusion, it must be remembered that the law concerns itself not only with companies incorporated in the United Kingdom, but also with those established outside, but which set up places of business in this country. Such companies must, within one month from the establishment of the place of business, file with the registrar a certified copy of the charter, statutes, or memorandum and articles of the company, and, if the instrument is not written in English, a certified translation. Also, there must be filed at the same time a list of directors and the names and addresses of some one or more persons resident in the United Kingdom authorised to accept on behalf of the company service of process and any notices required to be served on the company. In the event of any alteration being made in any such instrument, or in the directorate, or in the names and addresses of the persons afore-mentioned, the company must within the prescribed time file with the registrar a notice of the alteration. Any process or notice required to be served on the company is considered sufficiently served if addressed to any person whose name has been filed as already mentioned and left at or sent by post to the address so filed. Every company of this kind must each year file with the registrar such a statement in the form of a balance-sheet as would, if it were a company formed and registered under the Act, and having a share capital, be required to be included in the annual summary. Any company incorporated outside the United Kingdom which uses the word Limited as part of its name, and has a place of business in this country, must, in every prospectus inviting subscriptions for its shares or debentures in the United Kingdom, state the country in which the company is incorporated; and it must conspicuously exhibit on every place where it carries on business in the United Kingdom the name of the company and the country of incorporation.

CHARLES RAY

The Science of Crystallography. The Molecular Structure of Metals. Osmotic Pressure. The Problems of Solution.

CRYSTALLISATION AND SOLUTION

The Study of Crystals. We may briefly refer to another very important study which is also concerned with our conception of the three states of matter. This is the study of solidification and crystallisation. We can merely direct the reader's attention to the subject on three distinct grounds.

Firstly, we must recognise that the study of crystals will help us to understand the molecular structure of matter. We must believe that the varying shapes of crystals depend, in some way, upon the varying shapes of the molecules of which they are composed. We conceive of molecules, of course, in terms of *stereo-chemistry*—that is to say, in terms of three-dimensional space. In our recent studies, both in physics and chemistry, we have seen how different kinds of crystals are able—ultimately in consequence of their molecular structure—to produce remarkable changes in a beam of light, and we have also noticed the extraordinary fact that there are certain forms of life which have a selective affinity for crystals, or, rather, for molecules of certain shapes, but do not act upon other molecules which are identical in every way but for the one difference which corresponds to the difference between the right hand and the left, or between any object and its mirror image.

The Crystalline Structure of Metals. Secondly, the study of crystals and crystalline structure is now seen to be of extraordinary practical importance; just as all trees have flowers, though the flowers are inconspicuous, so the metals, though we do not readily recognise it, have a crystalline structure. Further, we find that to this crystalline structure, to these mutual relations of the molecules, must be referred the gross physical properties of any specimen of a metal. The ultimate difference between the rod of steel or the tube of steel which remains intact, and another which bursts on board a steamship and kills a dozen men with scalding steam, is to be found in crystalline structure, in the relations which the molecules assumed when the steel, or other metal under consideration, underwent the process of solidification. It is interesting to note that the microscope, invented in the interests of biology, and long used by biologists alone, now forms an invaluable part of the *armamentarium* of the metallurgist, who is enabled by its means to make minute study of the crystalline forms of various specimens of various metals and alloys, and to correlate differences in this respect with physical properties, such as brittleness, elasticity, density, and the like.

If the reader should ask where he must look for the most noteworthy advances in this subject, and for the most extensive knowledge, he may be referred to the University of Sheffield, the metallurgical work of which affords an admirable instance of that wise tendency towards specialisation which the universities of this country are now exhibiting.

Value of Crystallography in Industry. Our foremost authority on general crystallography, Dr. A. E. H. Tutton, F.R.S., speaking of his subject, has said: "Its bearing on engineering is of no trifling character, since the whole of the metallic materials employed by the engineer are crystalline substances. Hundreds of valuable lives have been sacrificed by the existence of flaws in metallic beams, girders, tie-rods, bolts, rails, wheels, and axles, consequent on local development of crystalline structure, or on the local separation of crystals of a particular constituent in an alloy or a steel. Many of these might have been saved if we had possessed exact knowledge of the crystallographical character of metals, and of the influence upon it of the various metallurgical and mechanical processes to which steels are subject. Investigations to this end are at length being tardily initiated, and the practical utility of this branch of crystallography is so obvious as to appeal to all, and from motives equally economic and humanitarian."

"Neither Alive nor Dead." Thirdly, the study of crystals is of the most extraordinary interest in relation to the problems of life. In the narrow sense crystals are not alive; but they display certain characters which strongly suggest that, from some points of view, they may be regarded as intermediate between the living and what we are pleased to call non-living.

Does all Matter Respond to Stimulation? A distinguished Indian physicist, Professor Chunder Bose, of the Presidency College, Calcutta, published in 1902 a remarkable book, entitled "Response in the Living and the Non-Living," in which he was enabled to show that various crystalline forms of matter exhibit response to electrical stimulation, and show fatigue and electrical phenomena identical with those which the physiologists have hitherto described as characteristic of living muscle. His work was met with the usual and necessary incredulity accorded to the pioneer, but his results have stood. He later published his "Plant Response," which carries his work still further, proving the identity of response to stimulation in the animal, in the plant, and in various kinds of crystalline inorganic matter. We may briefly quote from page 40 of Professor Bose's remarkable book, published in this country by Messrs. Longmans.

"By following the electrical method of inquiry which has just been described, I have been able to prove that the power of responding to stimulus, and, under certain conditions, the arrest of this power, is the characteristic, not of organic matter only, but of all matter, both organic and inorganic; and that, in general, the various agencies which bring on the modification of response in one case—such as fatigue, temperature changes, stimulating or depressing chemical reagents—act in the same way in the other. The capability of responding, so long regarded as the peculiar characteristic of the organic, is also found in the inorganic, and seems to depend in all cases, both qualitatively and quantitatively, on the condition of molecular mobility." Professor Bose has been giving important demonstrations in England at the Royal Institution and at Oxford and Cambridge, and the neglect of the past is now being very generously remedied.

All Elements have Crystalline Forms. We may conclude our brief review of this big subject by one or two more references to the work of Dr. Tutton, which is of extreme importance. He says:

"The fundamental fact of the science is that every solid chemical element, whether metallic or non-metallic, and every solid substance of definite chemical composition, be it naturally occurring or artifically prepared (with the exception of the few which have never yet been obtained in the crystalline condition owing to the great viscosity of their solutions or of their molecules when in the state of union), has its own definite crystalline form, which is just as much a characteristic feature of the substance, by which it can be identified, as is any one of its chemical or physical properties This is a statement which it has only quite recently been possible to make with certainty. For it was for a long time thought that the members of the numerous well-known series of analogous chemical compounds (which only differ in containing a different member of a family group of chemical elements as their dominating and generally metallic constituent) were absolutely identical in their crystalline form, and they were consequently classed as 'isomorphous.' But the author of this article has been able to prove, as the result of fifteen years' work, that although the forms are very similar, and although they belong to the same type of symmetry, the angles between their corresponding faces are different, to the extent, it may be, of only a few minutes of arc, but in some cases by as much as a couple of degrees. Moreover, the amount of difference is governed by a definite law, which connects the atomic weight of the metal or other dominating (acid-forming) element present with the whole of the properties of the crystals, whether of exterior form, of optical character, or of internal structure.

"The main result of the highest refinement of crystal measurement has been to establish the fact that perfectly developed crystals of the same chemical substance invariably exhibit faces inclined at precisely (to within one or two minutes of arc) the same angles, whatever may be the variations in the relative sizes of the different faces. In, brief, the interfacial angles of crystals of the same substance are constant, and are the peculiar property of that substance, differentiating it from all others."

The Problems of Solution. The moment we turn the mind to such a simple phenomenon as the melting of a lump of sugar in a cup of tea, we realise that, commonplace though this be, it is profoundly interesting, and must surely be profoundly important. In the present outline discussion of it we shall follow Mr. W. C. D. Whetham, F.R.S., whose "Theory of Solution" (John Murray) is the most authoritative book upon the subject.

The problems of solution are important on every score. They have always been recognised as important for the physicist and the chemist, but we have only of late years begun to recognise their extreme importance for the biologist and the physiologist. Indeed, the greater our knowledge of the facts of solution in general, the nearer we shall be towards understanding the facts of life in general, and notably of the facts of the relation between the infinitely complicated and numerous processes that are necessary for the life of the higher organisms. According to Mr. Whetham, "*the application of physical conceptions to the problem of living matter chiefly depends on the knowledge we possess of the physics and chemistry of ordinary solution.*"

It is of interest that the biologists were the pioneers in the modern elucidation of this subject, which began more than forty years ago. The biologist Traube, followed by Pfeffer, showed how to construct what are called "semi-permeable membranes," which will permit water to pass through them, but will completely arrest certain substances that may be dissolved in the water. These membranes are in general made of porous unglazed earthenware, which has been impregnated with certain salts. The remarkable fact is that such semi-permeable membranes are found almost everywhere within the bodies of animals and plants, and play, as we now know, a most important part in their life.

The Laws of Osmotic Pressure. If we prepare a cell the walls of which have this property, and fill it with a solution of sugar in water, while we bathe its exterior in pure water, we find that the water forces its way into the cell up to a certain point. This point can readily be measured if the cell has a glass tube containing mercury attached to it. Such a pressure gauge will indicate for us what is called the *osmotic pressure* of the solution after the maximum amount of water has forced its way into the cell from without.

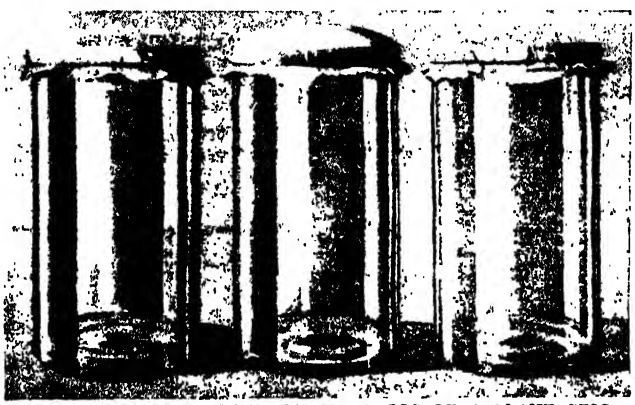
This osmotic pressure follows certain laws, and these have been elucidated by the most distinguished student physical chemistry has ever had, the late Professor Van't Hoff, of Berlin. We may quote the following two laws as stated by Mr. Whetham. The investigations pursued by Pfeffer show the following results.

(1) That the osmotic pressure was inversely proportional to the volume in which a given mass of sugar was confined.

(2) That the absolute value of the pressure in the case of the solution of sugar was the same as that which would be exerted by an equal number of molecules in a gas when placed in a vessel with the same volume as the solution.

These laws are of extraordinary interest, for they must instantly recall to our minds two other laws with which we have long been familiar, and of which these new laws are verily no more than extensions. We already know the law of Boyle, that the volume of a gas is inversely proportional to its pressure. We now discover that this general proposition holds true not only of gases but also of dilute solutions—evidently a splendid result.

Secondly, we know the law of Avogadro, which states that the pressure of a gas depends upon the number of molecules present and not upon their nature. We now discover that this law is true not only of gases but also of dilute solutions—a result which is equally splendid. Several workers have shown by other arguments "that the osmotic pressure must be equal in amount to the gaseous pressure exerted by the same number of molecules when vaporised, and must conform to the laws which describe the temperature, pressure, and volume relations of gaseous matter." This holds good whatever may be our precise theory of the nature of the process of solution. It may be almost impossible to frame any clear idea of what actually happens when sugar melts in tea, and yet we are enabled to frame laws of solution which are absolutely identical with the corresponding laws of gases.



HOW WATER GOES THROUGH THE WALLS OF A PLANT CELL.

[illegible]smosis, or the passing of moisture through the walls of a plant cell, is here rep[illegible]nted [illegible]hree wide-mouthed jars are taken. The first is filled with sugar solution, and a [illegible] [illegible] twenty-four hours, the covering membrane bulges outwards as in the second pict[illegible] Water has passed through it inwards, though no aperture exists. If the jar be now put for [illegible]e hours in water containing a stronger solution of sugar than the jar itself contains, the me[illegible] found to sink in, as in the third jar; water has passed through it outwards. So fl[illegible]ds pass through walls of plant cells.

Mixtures and Compounds Again. How far do these laws help us to determine whether solution implies the formation of anything that can be called a chemical compound, or whether it means no more than a mixture? Elsewhere, of course, we have seen evidence to show (in the case, for instance, of the relation between water and alcohol) that some chemical action must be involved; and on the whole the present evidence is rather in favour of the view that solution is a chemical rather than a purely physical fact; in other words, that "a solution, say, of salt and water is in some way a chemical compound of these components; a compound in which the relative proportions between the components can vary continuously between certain wide limits."

Explanation of Apparent Exceptions. It was soon discovered that there are certain noteworthy exceptions, as it would appear, to the usual law of the osmotic pressure. If we compare solutions of sugar and of alcohol, each containing the same number of molecules in the same volume, we find, as the law asserts, that they possess equal osmotic pressures; but if, instead of comparing sugar and alcohol, we compare sugar and salt, we find that, even though the two solutions contain equal numbers of molecules, the osmotic pressure of the salt, if the solution be fairly dilute, may be almost twice as high as that of the sugar.

It has remained for another great physical chemist, Professor Arrhenius, of Stockholm, to show that it is not necessary, as Van't Hoff supposed, to regard this case as an inexplicable exception. On the contrary, we have only to suppose that the molecules of the salt undergo a splitting up or dissociation, and we see that the abnormally high pressure may be explained. This dissociation is rendered much the more probable when we realise that these abnormal osmotic pressures are found in the case of solutions which conduct electricity.

What Happens to the Molecules. According to this now famous dissociation theory of Arrhenius, common salt does not exist as such when it occurs in dilute solution in water. The molecules have been dissociated, and exist as particles or atoms of sodium and chlorine, these being associated with electric charges. "Each salt molecule thus gives two pressure-producing particles in solution, and the double value of the osmotic pressure is explained. In stronger solutions, this dissociation is not complete, and the osmotic pressure is less than twice the normal value."

This theory, then, shows us that Van't Hoff's laws are valid, even in the case of apparent exceptions to them. It recognises that these exceptions consist of solutions of *electrolytes* as distinguished from non-electrolytes, this new term being applied to substances capable of conducting an electric current, meanwhile undergoing change; and it explains abnormalities of pressure in terms of molecular dissociation.

An entirely different method of studying the facts lends further support to the dissociation theory. In this subject Faraday was again the pioneer. He showed that there was a

constant proportion between the amount of electricity conveyed through an electrolyte, and the amount of decomposition which that electrolyte suffered. This seemed strongly to suggest that, when an electric current is conveyed through, for instance, a solution of sodium chloride in water, what really happens is a dissociation of the molecules of the salt, the positively electrified atoms of sodium going with the current, and the negatively electrified atoms of chlorine going against it. These "goers" Faraday termed "*ions*," a Greek term which has that meaning. The ion which moves with the stream, and toward the electrode which is called the cathode, is known as the *positive ion* or *cation*, while the ion which travels against the stream and moves toward the electrode which is known as the anode, is called the *negative ion*, or *anion*.

The Movement of Ions. We have here, perhaps, the very first hint that electricity, and even an electric current, is particulate and atomic in structure. Said Von Helmholtz in his Faraday Lecture of 1881, years before the discovery of radio-activity: "If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also is divided into definite elementary portions, which behave like atoms of electricity."

The next question which opened itself for study was plainly the character of the ionic movement. As we measure the conductivity of a solution by the amount of electricity which it will convey in a given time under the action of a given electric force, and as the conduction of the current depends upon the movement of charged ions, the conductivity of the solution, which is a measurable thing, must depend upon the *number* and *velocity* of the ions. Now, the number is ascertainable, because we can ascertain the strength of the solution, and thus we are in a position to ascertain the speed at which the ions move.

Mr. Whetham himself is largely responsible for the means by which we are now able actually to see the ionic movement—not, that is to say, the movement of the individual ions, but their movement *en masse*. This can be done by means of an apparatus which permits us to place next one another solutions of two salts, one coloured and the other colourless. Says Mr. Whetham: "The solutions should be of the same molecular concentration, the same conductivity, and the denser solution must, of course, be placed below the lighter. Let us take as an example the case of solutions of potassium bichromate and potassium carbonate, which fulfil the necessary conditions. The colour is here due to the acid part of the salt, the bichromate ion, which has the chemical composition represented by Cr_2O_7; the potassium ion is colourless. When a current of electricity is passed across the junction between the liquids the colour boundary is seen to move, and, from the rate at which it creeps along the tube, the velocity of the bichromate ion under a given electric force can be determined."

The Speed of Ions. The reader will almost certainly imagine that the speed with which the ions move will be very great, but it is really remarkably small. Much the fastest moving ion known is hydrogen, but when the electromotive force is one volt per centimetre the hydrogen ion moves only at the rate of 4 in. per hour, and this is about ten times as fast as the speed of most other ions. We must distinguish this movement, of course, from the movement of the electric current—or, rather, we must distinguish the two speeds. The movement of the current is almost as rapid as that of an electric wave—that is to say, is almost equal to the velocity of light. Mr. Whetham compares the two movements with the case of the movement of a stick. If we push one end of the stick, the whole of it moves on. Its velocity may be as slow as that of a hydrogen ion—a mere 4 in. per hour. But something else moves with an immeasurably greater rapidity, and that is the wave of compression which is induced by the push, and which must travel along the whole length of the rod before its advancing end can move. "The slow movement of the rod as a whole, when once started, corresponds with the slow drift of the ions; the almost instantaneous passage of the wave of compression along the rod corresponds with the velocity of electricity in the electrolytic solution."

What the Dissociation Theory Explains. The facts of solution and the facts of double decomposition, when fully considered, lead us to revise the idea that the dissociation of the electrolyte is due to the passage of electricity through it. It can be shown, indeed, that the electricity is not *used up* in dissociating the molecules of the electrolyte. There is already a good deal of freedom among the ions of the solute, or substance dissolved, even before the electric current passes. What the electricity does is merely to sort out the ions and force them to move against the resistance of the water. As to what solution really involves we cannot say. The ions of the solute must have relations which we cannot define with the molecules of the solvent, but they are, at any rate, independent of, or dissociated from, each other.

The dissociation theory does more than give us a complete explanation of the electrical and osmotic properties of solutions, or at least of aqueous solutions. It actually enables us to explain, in great degree, the chemical properties of such solutions—that is to say, it enables us to correlate their chemical and their electrical properties. The very solutions which exhibit the highest chemical activity are solutions of electrolytes—salts and acids—and their chemical activity is the activity of their ions. There are some chemical reactions in which "the electric charges on the ions seem to be the determining factors of the whole process."

C. W. SALEEBY

Its Early Use and its Nature. Its Manufacture and Method of Employment as a Substitute for Masonry. Faience in Building Construction.

TERRA-COTTA

TERRA-COTTA, as is implied by its name, consists of burnt or baked earth, and is a material that has been in use for building for a very long period. It was used in Assyria and Persia, both in the form of small cubes and also in large blocks moulded in relief and enriched with colour, for lining walls. The examples of this work from Susa to be seen at the Museum of the Louvre, Paris, exemplify the splendour and permanence of this material when so treated.

The Greeks made considerable use of it, especially for small buildings and for tiles and cornices, and they employed colour for enriching the surface; the Etruscans in Italy carried its manufacture to great perfection, and achieved results that would tax the skill of a modern manufacturer. Examples of their use of this material are to be seen in the British Museum, in the complete entablature of a small building, and in a series of remarkable covers to sarcophagi; on many of these figures of nearly life size are executed, the lid being in a single piece of terra-cotta.

Modern Use of Terra-cotta. This material continued to be used by the Romans for pipes and flues, and in mediæval times was extensively employed in Italy as a building material, and admirably treated; the courts of the Certosa at Pavia may be mentioned as examples of the successful use and treatment of terra-cotta by the Italians.

Italian workmen made use of terra-cotta in England quite early in the sixteenth century, and their work at Hampton Court and elsewhere is among the earliest examples of Renaissance work in this country. In modern times it has been very extensively employed both in combination with brick and as the exclusive material for facing. The Natural History Museum at South Kensington, London, is one of the earliest examples in England of an important building so treated, and the recent addition to the Savoy Hotel, facing the Strand, London, is one of the more recent and is an example of the use of a special texture on the surface.

Advantages of Terra-cotta in Building. As a substitute for masonry, terra-cotta has both advantages and disadvantages. Of the former, one of the chief is, that when well made it resists the attack of the acids contained in the atmosphere of towns much better than do most stones. It is of great strength—about 30 per cent. stronger than good Portland stone—and may be obtained in a variety of colours; the surface may be produced with a perfectly smooth texture, or one resembling that of masonry dressed with a chisel. It is light, and is employed in hollow blocks to the greatest advantage. In situations where it is not exposed to the weather, it may be made without a glazed surface; where it is to be covered with plaster or other materials, a slight amount of distortion is not a serious defect, and this material is largely used for lintols and partition-blocks in several systems of fireproof construction. For external work, as a substitute for masonry, it must have a surface glaze to resist the attacks of weather as well as those of the acids in the atmosphere; but when so used, if carefully designed and employed in large quantities, it is less costly than stone, and the forms may be enriched without the same cost as in the case of stonework, especially when there is much repetition.

Drawbacks to the Use of Terra-cotta. Some of the principal drawbacks to the use of terra-cotta are that the materials from which it is made are liable to shrinkage during drying and burning, and, unless great care be exercised in manufacture, they are liable to shrink irregularly, with the result that blocks become distorted and the salient lines are not straight but twisted. When once burnt, the finished face in exposed work must not be touched, and any such irregularity of line or form cannot therefore be corrected, for the material itself is generally porous, and if the protecting surface is interfered with, the weather rapidly attacks and destroys the terra-cotta. If the blocks are not thoroughly homogeneous, but have an external layer of finer clay formed upon blocks composed of coarser material, there may be unequal shrinkage between the materials; fine cracks then appear on the face, wet penetrates, and in severe weather freezes, and the face scales off. Both of these drawbacks may be to a very great extent overcome by care in manufacture, but a very serious disadvantage in these days of rapid construction is the delay that is unavoidable in supplying the material and, in particular, in replacing blocks that may be condemned as unsatisfactory. The process of manufacture covers a considerable time, and cannot be hurried, so that it may often take a month or more to replace a block that has been condemned. It is sometimes customary to provide duplicates of any particularly difficult blocks that are likely to show distortion, but this is a somewhat costly provision.

Nature of Terra-cotta. Being burnt from clay, it may be considered as a material analogous to brick, though it is more carefully prepared than brick earths; but in the manner of using it on a building, it is treated, so far as actual construction is concerned, more like masonry. The blocks are prepared in a different manner from masonry, for they are moulded and

burnt, not cut from a rough block; but so far as bonding and putting together are concerned, the practice of masonry is very closely followed; in dealing with actual construction in terra-cotta, therefore, we shall describe here only the variations in practice from ordinary masons' work, and for the treatment so far as it coincides with that of masonry the reader is referred to the articles on this subject which immediately follow.

Necessity for Detail Drawings. It is necessary for a terra-cotta building that the whole of the work should be detailed very accurately, including such matters as every variation in size of quoins and dressings round openings. In masonry in a similar case the moulding only would be detailed; but, as a rule, unless great uniformity be required, the height and width of each block is left to the discretion of the mason, and depends on the sizes of stones available. In terra-cotta, on the contrary, as each block is made in a mould, every dimension must be given, and must be carefully arranged so as to secure bond with the brick walling or backing with which it is usually combined.

The height of every course in such cases must, therefore, be an exact multiple of the height of a brick course, and if the bricks to be used are not of the ordinary size, but larger or smaller, the terra-cotta must, nevertheless, be designed to suit the bricks and bond with them. The width of the bed, exclusive of any projection from the face, must also be the multiple of the breadth of a brick dimension. In continuous strings, the length is more open to variation; but it is convenient that this, too, should be a multiple of a brick length, to facilitate the use of bonding blocks. In quoins and window dressings the difference in the width of face of successive blocks should be a multiple of the width of a closer to assist bond. It is also necessary to foresee and arrange for all grooves for plaster or lead work, sinkings for fixing joinery, window bars, iron balustrades, etc., as well as joggles, rebates, etc., for fixing and bonding the terra-cotta blocks together. In masonry many of such details can be cut in the stones when fixed, but in terra-cotta they must be provided for in the moulds from which the material is cast, or formed in the block when cast and before burning.

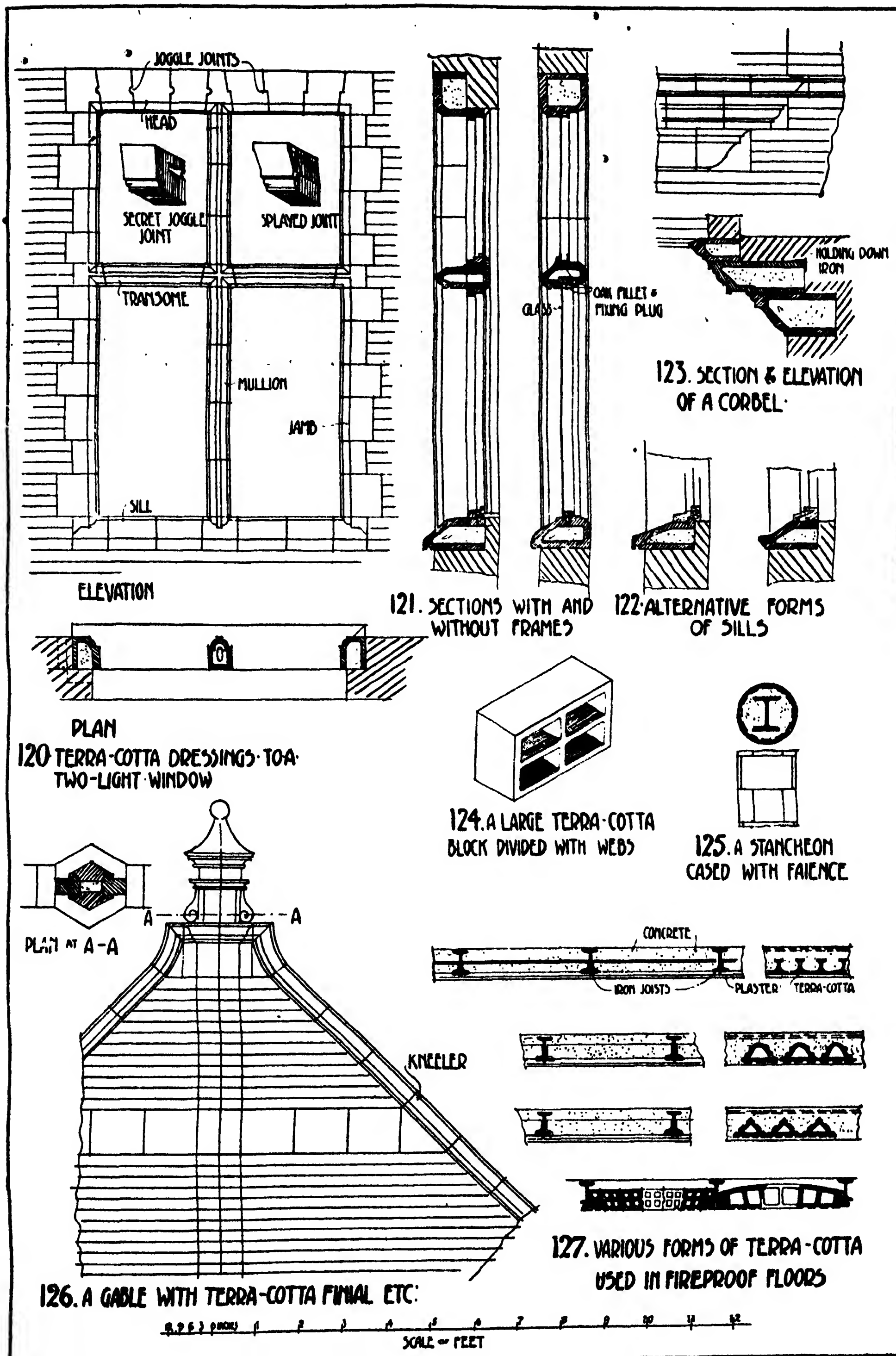
Use of Shrinkage Scales. The shrinkage of terra-cotta varies somewhat, but is considerable, and generally amounts to about $\frac{1}{12}$th of each dimension. The manufacturer must be informed if the full-size drawings represent the terra-cotta when moulded or after it has been burnt. It is often the practice to draw such details to the size of the blocks as they should be moulded, and manufacturers will supply scales, known as shrinkage scales, adequately enlarged to allow of the subsequent shrinkage to the intended size during drying and burning. It is very desirable that this method should be employed in all moulded and enriched work, for if the enlargement be left to the manufacturer, though the blocks may be correct, the character of the mouldings and enrichments may be modified in the process.

Chambering Terra-cotta. The blocks of terra-cotta are not solid as is the case with bricks or stone, but, as a rule, are hollow and have one face left open. The walls of the hollow block are kept of a uniform thickness, as far as possible, to avoid inequality in shrinkage, and are usually from 1 in. to 2 in. in thickness. If the blocks are large, cross webs are formed in the process of moulding, and these are both horizontal and vertical if necessary **[124]**; they subdivide the block into a series of chambers and serve to stiffen it, and to prevent undue distortion.

Sizes of Blocks. The individual blocks are strictly limited in size; no block can, as a rule, be formed with a cubic capacity exceeding about 3 ft., and for general purposes blocks of very much smaller size are desirable. The larger the block and the longer the surfaces and arrises the greater is the risk of distortion in the lines during the process of burning, but very much will depend on the character of the block to be used. If, for example, a block be a terminal block, as in the case of the cap to a small pier, the shape is regular, the shrinkage is likely to be regular, and for setting it is necessary merely to have a good horizontal surface for bedding on the pier; provided this is secured, a slight distortion in other portions will not be of serious moment, and may be unnoticeable. In the case of an angle block containing a group of mouldings, such as a cornice, the circumstances are different; this must have not only a true bed, but perfectly true vertical joints at each face, so that the lines of all the mouldings will carry on truly the same line in the adjoining block. It will readily be understood that any distortion is serious, and, owing to the irregular shape of the block, is more likely to occur if the block be a large one. Whenever a block is so distorted as to be unsuited for its position, there is no middle course open; the block must be used as it is produced from the kiln, or it must be rejected altogether and a new block substituted, with the consequent delay; the lines must not be corrected by chiselling, or any other work which would destroy the surface of the material.

Absorption. In terra-cotta, as in stone, the question of absorption has an important relation to the durability of the material. If water be readily absorbed, it is not merely liable to expand in case of frost and split the material, but may carry into the stone, in solution, acids that will tend to disintegrate the material. When used for external work, terra-cotta that will absorb more than 10 per cent. of its own weight should not be employed, and one that absorbs a smaller proportion is to be preferred. This does not apply to the light, porous terra-cotta often used in fireproof floors which is not exposed to the action of the weather.

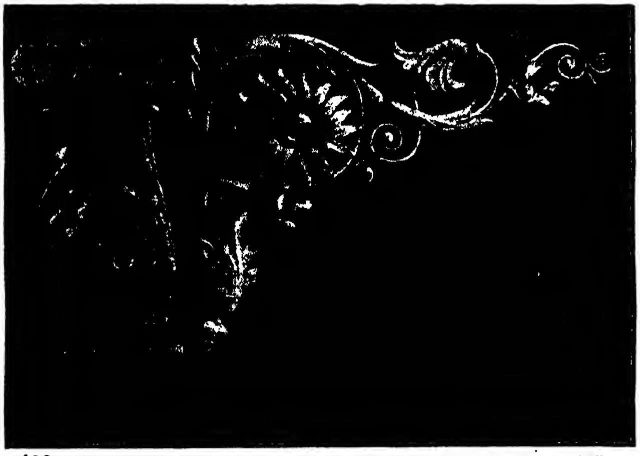
The Manufacture of Terra-cotta. The material from which terra-cotta is burnt is clay of a fine character—the best is refractory, containing a large proportion of silica; the presence of iron or of lime makes the terra-



120-127. THE USE OF TERRA-COTTA IN BUILDING

cotta more fusible and not so hard or durable; several varieties of clay, including fireclay, may be used. These vary in the amount of shrinkage, and they are often combined in various proportions to regulate the shrinkage, and other materials, such as sand and pounded pottery, not liable to shrink, are mixed with them so as to minimise it. The materials are finely ground in a dry state, placed in water, strained, pugged, well kneaded, and finally forced into the moulds.

In order to prepare moulds, models must first be made from the shrinkage scale drawings, including all enrichments. Such a model must be made for every piece of terra-cotta that differs in any respect from a model already made; and the economical employment of terra-cotta depends largely in reducing the number of models to a minimum. This is only to be secured by care in designing, and all unnecessary variations must be excluded. Moulds in plaster of Paris are taken from the models, the surface of the latter being smeared with soft-soap to prevent adherence. The moulds are made in sections in wooden boxes, and a large number of moulds can be taken from any model, but the moulds themselves have often to be renewed after a single filling. The clay must be well filled into the moulds, and after removal it may be slightly touched up; and any under-cut features are formed at this stage.



128. SPANDRIL AND BALUSTER IN BI-COLOUR TERRA-COTTA
By courtesy of Messrs. Doulton & Co.

Drying and Burning. The blocks are dried slowly with extreme care, and shielded from draughts, it being of great importance that all parts of the mould should dry uniformly. About half the shrinkage that takes place occurs during this process and before firing, and if one part of the block dries more rapidly than another, fine cracks may be set up and distortion occur.

When properly dried, the material is burnt in a pottery kiln in which the temperature is raised slowly, maintained at the requisite temperature till burning is complete, and allowed to cool slowly; the object throughout being to ensure that the further shrinkage which must occur during the process of burning shall be uniform in character. It is largely on this account that the blocks of material are moulded hollow; for were the blocks solid and of large size, there would be a tendency for the outer faces both to heat and to cool more rapidly than the centre, and cracks would be set up.

Marking and Filling the Blocks. The manufacturer marks and numbers every piece in accordance with general drawings, which show every block, and in building them in care must be taken to see that the blocks are used in the situations for which they are designed. On delivery at the building, the blocks must be carefully stored till required, and for most purposes, before fixing, the cavities or chambers in the blocks are filled up with fine concrete; they should be completely immersed in water for at least two hours before this is done, and the operation should on no account take place in frosty weather.

Lime concrete was formerly always used for this purpose, as having no tendency to expand and split the blocks while setting; but with the modern improvements in the manufacture of cement it is possible to use a thoroughly cool Portland cement without any fear of expansion sufficient to split the block. This process of filling adds strength to the block; it also adds weight; and in cases where lightness is of importance, as, for example, in a built-up cornice of considerable projection, it should be used in the lower blocks, whose principal bulk rests on the wall, to give stability, while the overhanging upper parts may be left unfilled. The open side of all such chambers is always arranged so as to come on the inner face of the block, and is entirely concealed within the wall. In floors, and in protecting steel work, the blocks are not filled, as the air space thus formed is a useful protection in itself.

Jointing Terra-cotta. When every care is taken, it is, in most cases, impossible to avoid some slight irregularity in the form of various blocks, so that were a straightedge applied to any plain surface, it would not be found absolutely true, and it is not possible, therefore, to lay terra-cotta with a fine joint, such as is used with squared masonry. The joint is usually rather thicker than an ordinary brick joint, and may be as much as ⅜ in., which should suffice to allow of any permissible irregularity being adjusted; it is necessary to bear this in mind in setting out terra-cotta work.

To avoid disputes during the progress of the work, it is usual for sample blocks to be deposited with the architect, showing the extreme limit of deviation from a true straight line that will be permitted; samples should also show the extreme range of variation in tint permitted, and if more than one colour is to be employed, this may be done for every colour to be used.

Setting the Blocks. In setting terra-cotta, the salient angle of which is moulded, or which carries a group of mouldings, as, for example, in a string or cornice, the setter must select the most prominent or important moulding by which to regulate his setting; for it will prove impossible, in some cases at least, where several mouldings occur, to set the block so that all the mouldings will run on in true lines. Every effort must be made to minimise the irregularity, and if the salient angles and important mouldings are free from obvious defects, the smaller intermediate mouldings will not attract attention, though small variations in line occur.

Colour of Terra-cotta. The colour of terra-cotta depends partly on the composition of the earth and partly on the temperature at which it is burnt. The usual colours to which terra-cotta is burnt are buff, red, white, and black, the last-mentioned being really a deep grey; two or more colours may be combined in a single elevation; or one colour may be selected for the terra-cotta and combined with brickwork of a colour that will harmonise with or form an effective contrast with it. Various other colours may be produced on terra-cotta surfaces, and while the surface is, as a rule, perfectly plain and smooth, terra-cotta is sometimes given a surface texture resembling that of masonry, or one somewhat resembling marble, as in the Savoy Hotel, London.

Its use may be confined to the more ornamental parts of a facade, such as the strings, cornices, and dressings round window and doors [120 and 126]; it is then described as moulded or enriched work; or it may be used for plain walling, so that the entire external surface of the building has a uniform facing of terra-cotta. In towns where the atmosphere is smoky, this latter treatment insures that the original appearance of the building will be less affected by the deposit of soot than where bricks with a rough surface are mingled with it. Where colour is applied to the surface of terra-cotta it is possible for decorative purposes to use more than one colour on the same block [128].

Forming Heads of Openings. The limitation in the size of blocks has been mentioned; in particular, it may be well to point out that a block, in which the length greatly exceeds either the breadth or thickness, is more liable to distortion than one in which all three dimensions are approximately the same. As a result of this limitation, it is impossible in terra-cotta construction to use long blocks as heads or sills to openings, or as mullions or transoms, in the manner usual in masonry. Such members, when employed, must be built up of a series of small blocks. In arches the terra-cotta is formed into blocks of voussoir shape, as in the case of masonry or gauged brickwork, but the blocks are much broader in face than is the case with brick voussoirs. In the case of a head the form known as a *flat arch*, already described in brickwork, is employed; in such cases, in addition to using the voussoir form for the blocks, the joint is further strengthened by the use of *joggles*, which serve to interlock the various blocks, and greatly strengthen the arch [120].

The Use of Joggled Joints. These joggles may run throughout the thickness of the block from the face to the back, in which case they will appear on the surface, or they may be concealed. In the latter case, they are stopped about 2 in. from the face, which has the appearance of a plain voussoir, the interlocking being arranged on the inner part of the block. Various forms of joggles are employed. A common form consists of a small semi-circular protuberance on one side of a block, which fits into a corresponding recess in the next block. Another method consists in breaking the lines

129. THE INTERIOR OF A GLASGOW FISH-SHOP
A beautiful example of appropriate ceramic treatment by Messrs. Doulton & Co.

enclosing the sides of the voussoir at about the centre of the length of the block, so that a narrow seating or rebate is formed. Both these forms, if executed in masonry, involve much labour and waste, and are rarely employed for lintols; but in forming the moulds in terra-cotta, little extra trouble or expense is involved, and the strength is considerably increased.

Forming Transoms and Mullions. In forming a *transom*, which is a horizontal bar dividing an opening into two heights, a springer is built into the jamb, and if there be a *mullion*, which is a vertical bar dividing the opening into two widths, into the mullion also [120]; if the width of the opening be moderate the intermediate length of transom may be formed in a single piece with a rebated and splayed joint as in a flat arch; with a wide opening it may be necessary to treat the transom as a flat arch formed of voussoirs. Mullions are built up of several blocks of terra-cotta placed vertically one above another. In the case of both mullions and

transoms it sometimes happens that the face is exposed to view all round, and in such cases the block cannot be formed with an opening at the back; it is then usual to leave both ends partially open in forming the blocks.

Forming Sills. Sills, like heads, must be formed in short lengths; in jointing them care should be taken to keep the first joint some little distance within the inner face of the jamb, or water running down the jamb will easily penetrate the joint. A terra-cotta sill may be grooved for a water-bar, as is usual with a stone sill [121], or a projecting tongue may be found on its upper surface which will fit into a groove in the wood sill and prevent any water passing under the latter [122]. Where the sill receives the jambs or a mullion, a small part of the jamb or mullion is formed in the same block as the sill, and forms a *stooling*.

Bonding the Jambs. In bonding the jambs of such an opening, in addition to increased width on the outer face, the blocks may be increased in thickness from back to front, so that a part of such blocks is built into the internal jamb whether it be square or splayed, the object of such projection being to improve the bonding of the jamb.

Stopped Mouldings and Corbels. Wherever a horizontal moulding does not run out, but is stopped and finished against another surface, it should be not merely butted against it, or in the case of a splayed surface, cut up against it; the moulding should be properly stopped against a terra-cotta face formed in the same block with it, and built into the abutting wall so as to give it a proper seating, and prevent wet entering at the joint [123]. Corbels should be formed in the same way; the projecting corbel, which may be moulded and enriched, should have a square seating in one piece with it for building into the wall. Large moulded corbels are sometimes built up of two or more courses of terra-cotta, to carry a bay window on an upper floor. These may start from the face of a straight wall and in the upper courses be worked into the form of an octagon or other polygonal figure, or of part of a circle.

Faience. *Faience* is a material somewhat akin to terra-cotta, and has been a good deal used in recent years for external as well as internal surfaces of walls. It is used in blocks similar to terra-cotta blocks, but these are formed of stoneware, and it can be made in rather larger sizes than terra-cotta. Stoneware is burnt from the plastic clays belonging to the Lias formation, which are found largely in the South of England, in Dorsetshire, and Devonshire; these clays contain about 76 parts of silica and 24 of alumina, with very small parts of other ingredients. In manufacture the clay is mixed with some unshrinkable materials, such as powdered burnt stoneware, ground flints, or sand, to prevent excessive shrinkage. The mixture is moulded like terra-cotta and carefully burnt in kilns at a high temperature, and becomes thoroughly vitrified throughout. The surface may be moulded or enriched much like terra-cotta; the material itself is not suitable in appearance for facing, but is covered with a glaze which may be arranged of almost any colour or tint, and permits of great variety in surface enrichment, producing, if skilfully treated, a varied, clean, and reliable surface, not liable to change its colour or to collect soot or dirt. The glaze employed may be an opaque glaze, as in the case of enamelled bricks, or a semi-transparent tinted glaze, which, with a slightly modelled surface, covers different parts of the block with varying thicknesses of the glass, producing delicate gradations in the tints. It is sometimes necessary with transparent glazes to cover the natural surface of the stoneware with a finer material composed of fine clay and applied as a *slip* to the terra-cotta before it is burnt, and this in turn receives the glaze and shows through it. So far as its use and application are concerned it is arranged for and treated in a manner similar to terra-cotta. A good example of its external use may be seen in a printing establishment at Bristol, erected by Doultons, Ltd.

Terra-cotta and Faience in Internal Work. These materials are not only used for external work as a substitute for masonry, but they are much employed in the interiors of buildings, and are of special value where it is desired to protect ironwork from the direct action of fire. Light terra-cotta blocks formed by burning a mixture of clay and sawdust, of which the latter burns out leaving a porous material, are much employed as a kind of permanent centre between the small joists in several kinds of fireproof floors [127]. These are usually about 2 ft. long, varying in section, and concrete is filled in above them; but the blocks are as a rule hollow, and are not filled with concrete. In other cases more solid floors are constructed, as flat arches and the springer blocks are made of such a form as to encase the flange of the girder which supports the arch, and for the sake of lightness such blocks are not filled with concrete. Terra-cotta blocks are employed also to form partitions in place of brick, and are also used hollow; in all such work the terra-cotta is usually concealed from view by a coating of plaster, and the surface of terra-cotta, when it is intended to be so covered, is frequently provided with a series of dovetailed grooves to give a key to the plaster which does not adhere perfectly to the smooth terra-cotta face. Where it is desired to display this covering or casing in the finished work and to treat it decoratively, faience may be applied and may be built up so as to enclose columns or stanchions [125]; but for such work the material is sometimes used, not in blocks of considerable thickness as for external building, but in slabs of about 2 in. or less in thickness; the outer surface moulded, modelled, and enriched with coloured glaze, the inner surface often keyed, when it may be used as a facing to concrete filled in round the ironwork. Internal walls and partitions may also be lined with Faience for purely decorative effect and render the use of appropriate designs possible [129].

R. ELSEY SMITH

Sharks and Rays. Sturgeons. Bony Fishes. Lung-Fishes. Lampreys and Hags. Lancelets, Sea-Squirts, and Acorn-headed Worms.

FISHES & PRIMITIVE VERTEBRATES

Fishes are aquatic, cold-blooded vertebrates with a defensive armour of scales or bony plates embedded in the skin. They breathe throughout life by means of gills, which are delicate folds or filaments connected with openings (gill slits) in the sides of the throat. Flattened expansions of the body—fins—are present, some of which, *unpaired,* are in the middle line, while others, *paired,* correspond to the fore and hind limbs of amphibians and the like. All the fins are supported by firm rods, the *fin-rays.*

Classification of Fishes. Four orders are recognised—namely: (1) Sharks and Rays (*Elasmobranchii*); (2) End-Mouthed Fishes (*Teleostomi*), divided into the three sub-orders of (*a*) fringe-finned fishes (*Crossopterygii*), (*b*) sturgeons and their allies (*Ganoidei*), (*c*) bony fishes (*Teleostei*), including the most common forms—for example, salmon, cod, mackerel, eel; (3) Lung Fishes (*Dipnoi*); (4) Lampreys and Hags (*Cyclostomata*). The last two orders differ so much from the others that they are often considered as separate classes.

Order 1. Sharks. The sharks and their small allies the dogfishes are the typical members of this order. The body is spindle-shaped, and well adapted to make its way through the water by wriggling movements from side to side. Propulsion is furthered by the largest of the unpaired fins—namely, the caudal, or tail fin, in front of which, on the upper side of the body, are two others of similar kinds, the dorsals, which help to balance the fish in the water. The front pair of paired fins (pectorals) are capable of a certain amount of movement, and help in steering the course, while the hinder paired fins (pelvics) are used as subordinate aids to swimming.

The unsymmetrical shape of the tail fin is particularly noteworthy, and is well seen in the illustration of a porbeagle shark [24]. These creatures are chiefly ground-feeders, and when they swim forwards without steering this sort of tail enables them to move directly downwards to the sea floor, which constitutes their chief area of operations. But by appropriate movements of the pectorals they can also swim straight ahead or obliquely upwards as may be desired.

It is characteristic that in members of this order the mouth should be on the under side of the head, a somewhat inconvenient situation, since to seize its prey the fish is obliged to turn over on to its back. Five gill slits are visible on either side in front of the pectoral fin; and just behind the eye there is an aperture known as the *spiracle,* which is the opening of a gill slit that is losing its use as a breathing organ, and serves to conduct waves of sound to the internal organs of hearing which are possessed by these fishes.

Tough Skin and Flesh. The skin of a shark or dogfish is extremely rough, owing to the presence of little bony structures, the placoid scales, which closely resemble teeth in nature. Indeed, near the edges of the jaws they gradually pass into teeth, which may be considered as evolved from modified scales—from which it follows that the possession of teeth by mammals, reptiles, and amphibia points to their descent from fish-like ancestors. Owing to the fact that the skin of a shark is full of sharp scales, it is capable of being used, under the name of "shagreen," for various polishing operations. The skin is also used in the manufacture of a kind of leather employed for ornamental purposes.

Sailors have long been in the habit of indulging in shark steaks, and the question has been raised as to whether dogfishes, the plague of fishermen, might not be used as food. The question can no doubt be answered in the affirmative, and, as a matter of fact, these fishes are often exposed for sale in some of our ports—Dover, for example.

Rays and Skates. These well-known fishes [6], rhomboidal in form, with a long, slender tail, are closely related to the sharks and dogfishes, with which they are connected by a series of transitional forms. They constitute an important article of diet. The edible part, from which "crimped skate" is prepared, consists of the triangular sides or "wings" of the body, which are no other than the enormously enlarged pectoral fins. Sharks, dogfishes, and skate alike are "gristly fishes," their skeletons being mostly composed of gristle, commonly hardened by the deposition of salts of lime.

The eggs of these forms are large, owing to the presence of a great deal of nutritive matter (food-yolk). They are fertilised internally, and may either develop within the body of the mother or be laid in horny cases, known popularly as "mermaid's purses" [18].

Order 2. End-mouthed Fishes. The name of this order is derived from the fact that, as a rule, the mouth has been shifted forwards to the front end, which is undoubtedly the most convenient place for it. The gill slits are protected by a flap, the gill cover or *operculum*, and the skeleton is more or less bony. A swim-bladder containing air is commonly present, its primary use being to help in balancing. The three sub-orders must be considered separately.

(*a*) **Fringe-finned Fishes.** These ancient forms are so called because the paired fins are in the form of large paddles bordered by a

membranous fringe supported by fin-rays. At a remote epoch of the earth's history they were represented by numerous marine types, but by pressure of competition were gradually driven into estuaries and rivers, and now only include two fresh-water African fishes. These are the bichir of the Nile (*Polypterus*) [1] and the slender reed-fish (*Calamoichthys*) [21], which lives in the rivers of Old Calabar. These forms are covered by rhomboidal bony plates, the tail fin is rounded, and there is a series of little finlets, each supported by a strong spine in front, running along the middle of the back.

(*b*) **Sturgeons and their Allies.** Here are included a small number of primitive fishes inhabiting the fresh waters and estuaries of the Northern Hemisphere, and in many cases so dissimilar that they would not be grouped together if it were not for the evidence afforded by extinct forms. This clearly shows that they are the surviving remnants of what was once a dominant marine group, and owe their preservation to the fact that they have taken refuge in the waters of the land, where the struggle for existence is not so keen as in the sea.

We may employ the term "ray-finned" in describing these fishes, for the thickened bases of the paired fins are largely absorbed into the body, so to speak, while their projecting parts are thin and supported by diverging fin-rays. The bony pike (*Lepidosteus*) of North America is clothed in bony armour, and its strongly toothed jaws are drawn out into a sort of narrow beak [9]. The widely distributed sturgeons are distinguished by the possession of a long snout, used apparently for stirring up mud in order to secure worms and other small creatures as food. The small mouth is on the under side of the body, as in sharks, to which another resemblance is afforded by the extremely unsymmetrical tail, in relation to the ground-feeding habit. Armour is sometimes entirely absent, or may be represented by large keeled plates, as in our only native form, the common sturgeon (*Acipenser sturio*), sometimes to be seen in fishmongers' shops [4]. The swim-bladders of European species are made into isinglass, and their hard roes are salted to be sold as caviare.

The bow-fin (*Amia*) of North America is not so archaic in appearance as the forms so far considered [12]. The tail is rounded, and the body covered with thin, flexible, overlapping scales.

(*c*) **Bony Fishes.** This large and dominant group, which still appears to be on the up-grade, includes the great majority of existing species, and represents the most perfect product of evolution, so far, along the fish line. It is true that sharks and rays (including something less than 300 species) are still flourishing, but the important forms now to be considered embrace no less than 7000 species, in round numbers.

The distinctive characters of bony fishes can largely be explained as adaptations to swift and accurately directed swimming. Some of them will readily be appreciated by examination of a herring, trout, or mackerel. The body is shaped like a rounded wedge, somewhat flattened from side to side, and eminently suited for sliding through the water with the minimum of friction.

Friction is still further reduced by the covering of thin, flexible, horny scales, bathed in a slimy secretion. Propulsion is effected by lateral undulations of the body, the effect of which is greatly enhanced by the powerful tail fin. The cumbrous armour-plating of the more ancient types has of necessity been abandoned, though it has been re-acquired by a few sluggish forms; and safety from foes is sought in speed rather than in defence. But as adequate support is required by the body, and firm attachments for the powerful muscles, the loss of a strong external skeleton is fully compensated for by the presence of a very elaborate internal skeleton largely consisting of bone [25].

The task of supporting the body in the water is to some extent lightened by the presence of a swim-bladder situated immediately below the backbone, obviously the best position for maintaining the balance. This organ is in reality a pouch, which grows out from the front part of the digestive tube, with which it may remain connected throughout life, as in the herring, or from which it may get separated off, as in cod.

Parachuting Fishes. It is particularly interesting to notice that in these fishes the tail fin is externally symmetrical, so that in unsteered swimming the course is straight ahead. A remarkable exception is afforded by the flying fishes, where the forked tail is markedly unsymmetrical, but with a large *lower* lobe, clearly for the purpose of giving an upward tendency to undirected swimming. And it is well known that these fishes, especially when pursued by their enemies, are in the habit of rising out of the water, and remaining for some time in the air, to which their enormous fore-fins, used as parachutes—not as wings—offer a very large supporting surface.

There can be no doubt that backboned animals were originally evolved in the sea, and it is therefore only to be expected that the organs of respiration and circulation in fishes should have become adapted to an aquatic life. Indeed, as we have previously had occasion to notice, the backboned animals of the land have been obliged to grapple with the difficulty of modifying the fish type of circulatory organs to suit the exigencies of terrestrial life. Amphibians and reptiles have done this to some extent, but only birds and mammals have completed the process, and it is to this fact that their success in life is due.

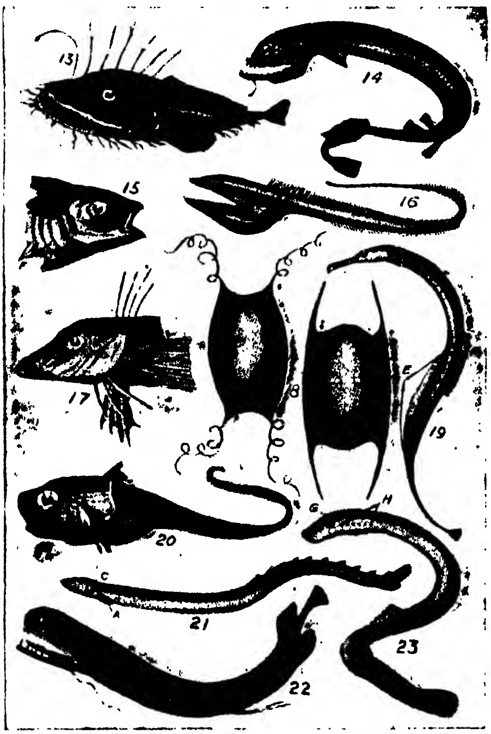
Structure of Gills. Anyone who takes the trouble to lift up the gill cover of a herring, or other bony fish, will at once see several comb-shaped aggregates of scarlet gill filaments, collectively presenting a large surface for the purification of the blood [15]. They are attached to narrow bony bars, between which are the gill slits. The course of the water used in breathing can easily be observed in an aquarium of goldfish. It is taken in at the mouth, passes through the gill slits over the gills, and thence

TWELVE REPRESENTATIVE FISHES

1. Bichir (*Polypterus*) **2.** Australian Lung Fish (*Ceratodus*) **3.** Seahorse (*Hippocampus*) **4.** Common Sturgeon (*Acipenser sturio*) **5.** Hag (*Myxine glutinosa*) **6.** Ray (*Raia*) **7.** Swordfish (*Xiphias gladius*) **8.** South American Lung Fish (*Lepidosiren*) **9.** Bony Pike (*Lepidosteus*) **10.** Globe Fish (*Diodon*) **11.** Coffer Fish (*Ostracion*) **12.** Bow-fin (*Amia*):
A. Pectoral fin *B.* Pelvic fin *C.* Gill cover *D.* Mouth *E.* Pouch

to the exterior. The heart receives impure blood from all parts of the body, pumps it to the gills for purification, and from these it flows to all the organs.

Many points in the life-histories of bony fishes are worthy of special study. The small eggs are fertilised externally, and in the large majority of marine species float on the surface of the water, though some of them—for example, those of the herring—are sticky and adhere to stones, etc., on the bottom. In some of the shore fishes, such as the little blennies, they are enclosed in protective capsules. The fry, or larvæ, which hatch out from the eggs are very unlike the adults in appearance, and have to pass through many changes before acquiring the characters of the species to which they may happen to belong. Both eggs and fry are eagerly sought out as food by a host of enemies, but they are produced in immense numbers, so that extinction is prevented. The hard roe of a cod, for instance, has been calculated to produce over nine million eggs each season.



13. Angler-fish. 14. Stomias. 15. Gills of Perch. 16. Saccopharynx. 17. Gurnard. 18. Mermaid's purses (A. Dogfish; B. Skate). 19. Pipe-fish. 20. Macrurus. 21. Reed-fish. 22. Malacosteus. 23. Lamprey.
A. Pectoral fin. C. Gill cover. E. Pouch. F. Gills. G. Nostril. H. Gill slits

Colouration. The colouration of fishes is to a large extent protective, rendering them inconspicuous by harmonising with the surroundings. Seen from above, the darker upper side is confused with the dark sea-floor; seen from below, the white or pale under surface blends with the glimmering background caused by the penetration of light into the water; seen from the side, the "reversed shading" takes away from the appearance of solidity, as already described for many of the backboned animals of the land. In many cases the colours change to suit different surroundings. During the spawning season some fishes, usually the males, assume bright courtship colours. The most familiar example is that of the little sticklebacks (*Gasterosteus*) of our inland streams, in which at this time the male (then known as a "robin") arrays himself in a scarlet livery, and is unusually pugnacious, fighting to the death other suitors who attempt to interfere.

Care of the Young. Parental affection among fishes is usually notorious by its absence. But to this there are some honourable exceptions, and in such cases fewer eggs are produced, for each has a better chance of hatching out into a larva destined to attain maturity. In one of the fresh-water catfishes (*Aspredo*), for example, the eggs are attached to the roughened under surface of the mother's body. Strange to say however, it is to the paternal side that we must mostly look for examples of the care of eggs or young. The sticklebacks are well known in this connection. The male constructs a muff-shaped nest, made up of fragments glued together by a sticky secretion of the kidneys. In this his wives lay their eggs, which he jealously guards till they hatch out, a procedure rendered necessary by the depraved cannibalistic tendencies of the females; and when the tiny fry emerge he protects them for some time. The male of the curious little seahorse (*Hippocampus*), which holds on to seaweeds by means of its curly tail, has a sort of pouch on the under side of the body, in which the eggs pass through their development, and which serves as a city of refuge for the fry [3]. The same is true of the pipe-fish (*Syngnathus*), a related form [19].

Salmon and eels are curious instances of precautions taken for the benefit of the rising generation. It is a familiar fact that the former ascend rivers to spawn, the eggs being deposited in a sort of trench scooped out in the gravel or sand at the bottom. Exactly the reverse is true of eels, for it has been discovered of late years that they descend rivers to spawn in the deep sea, from which later on the little "elvers" return to the proper home of the species.

Adaptation to Circumstances. The great bulk of bony fishes resemble the herring and trout in shape, but there are, of course, considerable differences in detail, which may be illustrated by comparing the blunt-headed gurnards [17] with the sharp-snouted sword-fishes [7]. There are also very considerable variations in the character of the fins, and even their number in the case of those which are unpaired. The original position of the hind fins (*pelvics*) appears to have been pretty far back, but there is a tendency for them to shift forwards, till in some cases they lie under the throat [25], being actually in front of the fore fins (*pectorals*).

But there are far more considerable deviations from the average type than those just mentioned.

Sometimes the body is long and narrow, as in pipe-fishes [19] and eels. In the former an advantage is gained when prey is being stalked on the sea-floor, for a body so shaped is very inconspicuous when seen from the front. The slimy cylindrical eel can easily wriggle through mud in the search for worms and molluscs. The sea-horse (*Hippocampus*), a fairly near relative of the stickleback, is sufficiently remarkable [3]. The

A considerable number of bony fishes are flat in shape, the flattening being from side to side, not from above downwards, as in skates and rays. Some such forms, for example, the John Dory (*Zeus faber*), swim with the body vertically disposed, and are likely to escape the notice of prey which happen to be in front of them; but the flat fishes par excellence (turbot, sole, plaice, and the like) are ground forms which, so to

24. SKELETON OF A PORBEAGLE SHARK

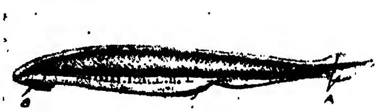
25. SKELETON OF A CODFISH

A. Dorsal fin. B. Tail fin. C. Peloric fin. D. Pectoral fin. E. Gill arches. F. Gill cover. G. Eye. H. Jaws

long axis of the body is here directed upwards, and the head has been sharply bent down, as otherwise it would be in an unfavourable position for seeing and seizing food. This curious little fish is able to swim in a vertical position by the rapid movement of the dorsal fin from side to side.

Methods of Securing Food. Sometimes the head is of disproportionate size, as in some forms which are not good swimmers, but lurk under stones or elsewhere on the look-out for prey. The bullheads of our shores and streams are examples of this. A still more conspicuous case is that of the angler-fish, or fishing-frog (*Lophius*) [13], which half buries itself in sand or mud, awaiting the approach of little fishes, which are attracted by a peculiar "lure" constituted by a much elongated fin-ray with a flap at the end. Such curiosity is commonly fatal, and there is no escape from the huge

speak, lie down on the right or left side of the body, and either shuffle along or swim by undulating movements. In a plaice, for example, the dark surface of the body, mottled with orange spots, is not the upper but the right side, while the pale left side is directed downwards. It is obvious that the left eye, if retained in its proper place, would not merely be useless but liable to injury by friction against the sea-floor, and in the course of development it moves round the edge of the head on to the right side. To begin with, the young fish is symmetrical, and swims in the usual fashion, but gradually becomes lop-sided and takes to living on the bottom. It is then that the left eye shifts its position. In most flat fishes both eyes are on the right side, as in the plaice, but in turbot and brill they are on the left.



26. LANCELET
A. Tail fin B. Mouth

The most remarkable and weird-looking bony fishes live at great depths in the sea, and suggest

27. SIMPLE SEA-SQUIRT 28. LARVA OF SEA-SQUIRT

29. A GROUP OF COLONIAL SEA-SQUIRTS

30. BALANOGLOSSUS

mouth, with its long, sharp, backwardly curved teeth, which bend down to facilitate entry, but render exit almost impossible. There are some deep-sea anglers in which the lure is phosphorescent.

Sometimes the body has acquired a rounded shape, as in the globe-fishes (*Diodon* and *Tetrodon*) of tropical seas [10]. These are able to blow themselves up with air and drift about back downwards with their sharp spines erected for defensive purposes. The coffer-fish (*Ostracion*) also deviates from the normal type, and is further distinguished by its armour of bony plates [11].

dream visions caused by acute indigestion rather than matter-of-fact living beings. Stomias [14], malacosteus [22], macrurus [20], and saccopharynx [16] are extremely voracious, with huge mouths and business-like teeth, and their eyes are either very large or much reduced; sometimes, indeed, absent. Many are studded with phosphorescent organs; and without light of this kind, supplied by various creatures, the abyss of the ocean would be dark indeed. Probably these unfortunate creatures have been driven into the deep sea from shallower waters by the stress of competition, and their peculiar characters are adaptations to an unusual sort of life.

Order 3. Lung-Fishes. It may be taken as an axiom that in all cases where more or less impure blood is separated by a thin membrane, either from air or from water in which air is dissolved, a certain amount of respiration will take place—that is to say, oxygen will diffuse into the blood, and the waste product, carbonic acid gas, will diffuse out of it. The swim-bladder of fishes offers an opportunity of this kind, for numerous blood-vessels run in its walls, and it contains air, or a mixture of gases, of which one is oxygen. It is well known that in the polypterus of the Nile, the bow-fin of the North American lakes, and certain bony fishes inhabiting fresh water, breathing is furthered in this way. The process has gone a stage further in the lung-fishes, which are at present represented by three fresh-water types, the insignificant remnant of a group that was once dominant in the sea, and would have become entirely extinct if some of its members had not taken to live in the waters of the land. These types are the eel-shaped mud-fishes of West Africa (*Protopterus*) and South America (*Lepidosiren*) [8], and a Queensland form (*Ceratodus*) [2]. In all these the swim-bladder has been converted into a regular lung, which returns purified blood to the heart. The African form lives in streams which are liable to dry up, and were it not for the possession of a kind of lung capable of breathing air would perish during the dry season, whereas it remains embedded in the mud in a torpid state till the rains return.

The Queensland lung-fish lives under somewhat different conditions, for its native rivers do not entirely dry up, but are reduced to a series of deep holes connected by mere trickles of water. These holes become so foul from decaying vegetation and dead fish that the possession of a lung is a vital matter, and if the ceratodus were not able to come to the surface and breathe air it would probably succumb.

Order 4. Lampreys and Hags. These eel-shaped forms are represented in Britain by the fresh-water lampern (*Petromyzon fluviatilis*), the sea-lamprey (*P. marinus*) [23], and the marine hag-fish (*Myxine glutinosa*) [5]. All of these are jawless, and the mouth is in the middle of a sort of sucker, studded with horny teeth, some of which are also present on a so-called tongue.

PRIMITIVE VERTEBRATES

There are three chief features by which backboned animals are distinguished—namely, (1) the central nervous system is tubular, and is situated near the upper side of the body; (2) underneath part or all of this a longitudinal supporting rod, the *notochord*, is present at some time or other during life, being, as a rule, entirely or partly replaced by a backbone in the adult; (3) the throat is perforated by gill slits during part or all of life. If these characters are taken as tests, the backboned animals include not only mammals, birds, reptiles, amphibians, and fishes, but also three other groups, the members of which are unfamiliar to all but specialists. These are: (1) LANCELETS (*Cephalochorda*); (2) SEA-SQUIRTS or ASCIDIANS (*Tunicata*); (3) ACORN-HEADED WORMS (*Hemichorda*), and similar forms.

Lancelets. The lancelet (*Amphioxus*) [26] is a little, flattened animal some two inches long, of very wide distribution, and formerly considered as a primitive sort of fish. It is in possession of all three characteristics mentioned above, but, like the lampreys and hags and all primitive backboned animals, is jawless. It is sharply pointed at either end, whence the name, and burrows in shallow water where the sea bottom is sandy. When feeding, it is embedded in the sand in a vertical position, and water flows into its bell-shaped mouth, serving both for breathing purposes and also to convey the minute organisms which serve as food.

Sea-Squirts. Living in the sea, and attached to various objects, are to be found a number of curious animals resembling in shape one of the wine-skins of ancient times, and covered by a tough protective investment [27]. There are two openings in the body, into one of which currents of water continually flow for feeding and breathing purposes, while waste products of all kinds are as continually swept out of the other. On dissection we find that the equivalents of gill slits are present, but there is nothing to represent a backbone, and the central nervous system consists of a little thickening between the two openings of the body, which is no help to classification. From the eggs of this curious creature, tadpole-shaped larvæ [28] hatch out, which satisfy all three of our tests, except that the notochord is limited to the tail region. Later on they become attached, lose their tails and notochords, and at the same time the central nervous system becomes reduced.

Many of the sea-squirts are colonial, consisting of a number of individuals connected together, and these may be either attached or free-swimming [29].

Acorn-Headed Worms. The best-known members of this small group are the acorn-headed worms (*Balanoglossus*) [30], which burrow in mud by means of the projecting front end of the body, which alternately elongates and shortens, the second process pulling the animal forward. A short elastic rod by which this region is supported possibly represents a notochord, while numerous gill slits are to be seen on the upper side of the body, and the central nervous system, though ill-developed, is situated as in typical backboned animals.

These creatures are protected by a disagreeable smell, and are brightly coloured, the two sexes differing in this respect. They are, perhaps, the nearest living representatives of the stock from which all backboned animals have descended.

It is a matter of great doubt which group of the innumerable backboneless animals, which we must next consider, comes closest to the backboned forms. There are, however, certain unsegmented marine worms (*Nemertines*), devoid of gill slits, notochord, and hollow central nervous system placed dorsally, but approaching backboned animals in some respects.

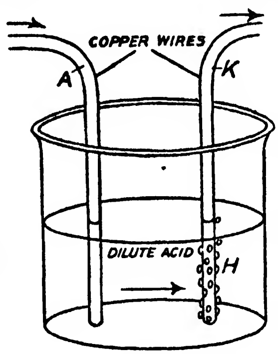
J. R. AINSWORTH-DAVIS

Decomposition of Liquids. Electrolytes. The Migration of Ions. Deposition of Copper. Laws of Electrolysis. Electrochemical Processes.

ELECTROLYSIS

ALLUSION was made on page 369 to the circumstance that liquids conduct electric currents. All liquids do not; for the oils are non-conductors. Those liquids that conduct may be divided into two classes: (1) those like quick-silver and molten lead which conduct simply as metals; and (2) those which conduct only while undergoing chemical decomposition. To this last class belong solutions in water of innumerable salts such as alum, saltpetre, sulphate of copper (blue vitriol), and the metallic salts generally, acids, solutions of alkalies, fused caustic alkalies, and fused salts. Absolutely pure water does not conduct at all, but ordinary tap water, which contains small quantities of salts in solution, conducts, and is made a better conductor by adding a little acid or soluble salt of any kind.

Electrolytes. Any liquid of this class was termed by Faraday an *electrolyte*, which means that it is decomposed when electricity passes through it. A simple experiment will enable us to understand the fundamental fact. Place in a small glass vessel, as in **239**, some water that has been rendered conductive by adding to it a few drops of sulphuric acid. Procure a small battery consisting of at least two cells, and with this battery send a current through the water by dipping into it the ends of the two wires which lead respectively from and to the battery. The wire by which the current enters the water is termed the *anode*, and that by which it leaves the water to return to the battery is the *kathode*. If these wires are of copper it will be found that, while the current is thus passing through the water, small bubbles of gas are given off at the kathode, while the anode becomes discoloured and will slowly dissolve, the liquid around it becoming of the blue tinge of copper sulphate. The bubbles which come off at the kathode, if examined chemically, are found to consist of hydrogen gas. This can be proved by collecting them in a test-tube and observing that they will burn. Let the experiment then be repeated, using bits of platinum wire to dip into the water, platinum being chosen because it is insoluble. It will then be noticed that bubbles of gas come off at both of the wires. The bubbles at the kathode are hydrogen, but those given off at the anode are oxygen gas. It is one of the most elementary facts of chemistry that water is a compound of hydrogen and oxygen; and in both these experiments water has been decomposed. When it is required to collect the gases separately, with a view to measuring the quantities given off, the form of apparatus shown in **240** may be used. With this the measurements can be made with extreme accuracy, and by the first law of electrolysis [see later paragraph] this forms a fundamental standard by which current-integrating instruments can be calibrated. When used in this way, the apparatus is known as a *voltameter*. When the copper wires were used in the water, the oxygen did not bubble off, because it joined itself to the copper to form oxide of copper, which was rapidly dissolved by the acid in the water.



239
LIBERATION OF HYDROGEN FROM WATER
A. Anode K. Kathode

Electrolysis. Decomposition of a liquid by the passage of an electric current through it is a sort of *electric analysis*; but this term was shortened by Faraday first to *electro-analysis* and afterwards to *electrolysis*. One of the most fundamental facts about the electrolysis of liquids is that the liquid is apparently not decomposed all along the path traversed by the current in the liquid, for the products of the decomposition come off only at the electrodes, where the current enters or leaves the liquid. When any acid is thus decomposed, hydrogen gas is produced, and it apparently travels through the liquid, being carried invisibly along by the electricity, and is deposited at the place where the electricity leaves the liquid, namely at the surface of the kathode. If strong hydrochloric acid is decomposed by a current, hydrogen is given off at the kathode and chlorine gas at the anode. The substances such as oxygen, chlorine, sulphur, etc., which appear at the anode apparently travel through the liquid in the direction opposite to that in which the electricity is travelling, and others, including hydrogen and all the metals, are invisibly conducted through the liquid in the same direction as the electric current flows. There are various theories to account for this, but we need not trouble about them.

The Ions. Whenever electricity is passed through an electrolyte, some of the molecules are split up into two parts, which then travel opposite ways, one part going *with* the current to the kathode, the other part going against the current to the anode. To these travelling parts of the molecules Faraday gave the name of *the ions*, a term of Greek derivation which means *the things which travel*. In some cases the ions consist chemically of simple atoms,

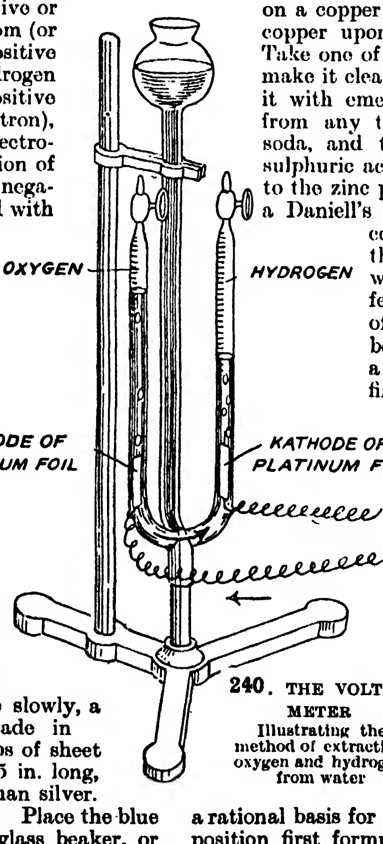
as hydrogen, or chlorine, or copper; in other cases the ion may consist of a group of atoms such as SO_4 or CN. Those ions which travel to the kathode are called *kathions;* those travelling toward the anode are called *anions.*

The following is a statement of a few electrolytes and of the ions into which they are decomposed:

Electrolyte.	Chemical Symbol.	Kathion.	Anion.
Water	H_2O	H	O
Concentrated Hydrochloric Acid..	HCl	H	Cl
Common Salt ..	NaCl	Na	Cl
Sulphuric Acid ..	H_2SO_4	H	SO_4
Sulphate of Copper	$CuSO_4$	Cu	SO_4
Cyanide of Silver..	AgCN	Ag	CN

Migration of the Ions. According to modern views each such ion possesses an elementary electric charge, positive or negative, associated with the atom (or atomic group) of matter. A positive ion, consisting of an atom (of hydrogen or metal) associated with a positive atomic charge (or positive electron), will, when subjected to an electromotive force, travel in the direction of that electromotive force, while a negative ion, because it is associated with a negative atomic charge (or negative electron), will travel in the opposite direction, and will move toward the anode. It has been shown that each kind of ion migrates with a definite velocity, proportional to the number of volts per inch of path between the electrodes.

Electrolysis of Metallic Solutions. Another very simple experiment [241] in electrolysis is afforded by the decomposition of a copper salt, and the deposit of metallic copper. For this purpose procure an ounce or two of the blue crystals of sulphate of copper—often called blue vitriol—and dissolve a few of them in water, producing a blue solution. As they dissolve slowly, a strong solution cannot be made in hurry. Procure also a few strips of sheet copper ½ in. broad and 4 in. or 5 in. long, and some similar strips of German silver. They should be carefully cleaned. Place the blue solution in a glass trough or a glass beaker, or even in a common jam pot, and add one or two drops of sulphuric acid to improve the conductivity. Use as source of current a single Leclanché cell. Connect copper wires to two of the copper strips, and join one to the carbon pole of the Leclanché cell, the other to the zinc pole. When all is ready, dip the two copper strips into the vessel containing the blue electrolyte, and watch what occurs during the next twenty minutes. If all is right, there will not be any bubbles of gas given off, but a deposit of fine red metallic copper will occur on the kathode (the metal strip joined by wire to the zinc pole of the cell), while the copper plate that serves as anode will be observed to become discoloured, and some of it will be dissolved. In fact, in this experiment copper is dissolved away from the anode and an equal quantity deposited on the kathode. The equality between the amount of copper dissolved off the anode and that deposited on the kathode can be tested by weighing both of them before the experiment is made, and by weighing them again afterwards. The gain in weight of the kathode ought precisely to equal the loss in weight of the anode. If the current has been too strong in proportion to the size of the kathode, or if the solution has been too weak, the loss and gain may not be equal, owing to the evolution of gases as well. After having thus deposited copper on a copper kathode, now try to deposit copper upon a strip of German silver. Take one of the German silver strips and make it clean and bright first by scouring it with emery paper, then cleansing it from any trace of grease with caustic soda, and then washing it with dilute sulphuric acid. Join it by a copper wire to the zinc pole of the Leclanché cell (or a Daniell's cell) and immerse it in the copper solution. As anode in this experiment a copper strip will be appropriate. In a very few minutes the white surface of the German silver plate will be found to be covered with a beautiful film of red copper firmly adherent to its surface. In fact, it is now copper-plated. It is not advisable to try to deposit copper in this way upon a surface of iron or zinc, because these metals are themselves electropositive to copper. If copper is to be deposited on iron or zinc, an acid solution must not be used, but a special alkaline cyanide solution of copper.

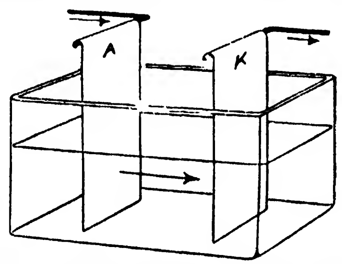


240. THE VOLTAMETER
Illustrating the method of extracting oxygen and hydrogen from water

Laws of Electrolysis. In the light afforded above by the paragraph on the ions, it is easy to see that there is a rational basis for the law of electrolytic decomposition first formulated by Faraday, that the quantity of chemical decomposition that goes on in any electrolytic cell is proportional to the total quantity of electricity that has been passed through the cell. So, if we know how much copper was deposited on the kathode by a current of one ampere in one hour, it becomes a simple matter to calculate by rule-of-three how much copper would be deposited by any other number of amperes in any given time that the current is maintained. Experiment shows

that a current of one ampere maintained for one hour deposits 18·22 British grains, or 1·181 grammes of copper. Since 1 lb. equals 7,000 grains, it follows that to deposit 1 lb. of copper will require one ampere maintained for 384 hours, or 384 amperes maintained for one hour. The simplest way of stating this is is to say that the deposition of 1 lb. of copper needs 384 ampere-hours. In the textbooks the electrolytic equivalents are generally given in terms of the number of grammes deposited by one ampere in one second. For copper this equivalent is 0·0003281 grammes.

Another of the laws discovered by Faraday is that when we compare different chemical elements with one another the amounts deposited electrolytically (by the same current for the same time) are proportional respectively to their chemical equivalents—that is, to the proportions in which in chemical reactions they are equivalent for exchange. The chemists take hydrogen as standard, and tell us that the amount that is "equivalent" for exchange purposes to one gramme of hydrogen is 31·59 grammes of copper, or 107·67 grammes of silver, and so forth. Hence we may construct a table of electrochemical equivalents as follows:



241. DECOMPOSITION OF SULPHATE OF COPPER
A. Anode K. Kathode

Element.	Atomic Weight.	Valency	Chemical Equivalent.	Grammes per ampere-second.	Pounds for 1,000 ampere-hours.
Hydrogen	1	1	1	0·00001038	0·824
Copper ..	63·18	2	31·59	0·0003281	·27
Silver ..	107·67	1	107·67	0·0011181	·9
Gold ..	196·2	3	65·4	0·0006791	53·7
Nickel ..	58·6	2	29·2	0·0003043	24·1

Voltage Necessary for Electrolytic Decomposition. If we try to decompose water with the use of a single Daniell cell, whose electromotive force is 1·07 volts, or even a single Leclanché cell, whose electromotive force is 1·5 volts, and terminal voltage, therefore, something less, we shall find that there is no evolution of gas at the electrodes if they are of a non-oxidisable metal, such as platinum, and that no current is carried through the liquid. If, however, we use two cells, the process goes on as already described. The reason of this phenomenon is that a certain minimum voltage (1·47 in the case of water) is required to break up the molecules of the liquid into its positive and negative ions, and so enable them to be deposited at the kathode and the anode. Under the influence of a voltage less than this the liquid is not conductive, and this voltage is a measure of the chemical affinity of the two elements or ions for one another.

If, however, electrodes of zinc or of copper are used, one cell will decompose the water because each of the oxidisable metals has an affinity for the oxygen of the water. Thus, for instance, copper has an affinity of about 0·8 volts for oxygen, and if a piece of copper is placed in water, or in a solution of a copper salt, it tends to dissolve into that liquid with an electromotive force of about 0·8 volts. It does not, however, dissolve, because it could only decompose the water by tearing away H from O, and this needs 1·47 volts. But if one Daniell's cell is applied, as in the experiment above, to the copper electrodes, the voltage of the cell adds itself to the affinity voltage of the copper anode, so that there is more than 1·47 volts acting.

Energy Required for Depositing. In electrotyping, where the anode and kathode are both copper surfaces, each tends to dissolve back into the liquid, these tendencies being equal and opposite. Hence, when even the smallest electromotive force is applied, it will cause a small current to flow from the anode to the kathode, for copper will be dissolved off at the anode, and an equal quantity will be deposited at the kathode. In a reciprocal action like this, the energy required is only that necessary to drive the current through the ohmic resistance of the liquid, and it all disappears in the form of heat. In other cases, where the anode and the metal deposited at the kathode, as, for instance, in the deposition of hydrogen in the electrolysis of water, a certain amount of work is required to overcome the chemical affinity of the constituents for one another, and an extra amount of energy is required which is transformed from electrical energy into chemical energy, which is rendered potential, and may be recovered and made to do useful work.

Industrial Uses. Electro-chemical processes are being increasingly adopted in industrial work. A great part of the copper used in electrical work is purified by being electrochemically deposited. Electrically deposited copper is so much purer than the ordinary product that its manufacture on a vast scale is a commercially profitable undertaking.

Another extended application is the manufacture of bleaching and disinfecting solutions. In these cases solutions of common salt (sodium chloride) or mixtures of sodium and magnesium chlorides are electrolysed, with the result that free chlorine is liberated at the anode and dissolved in the solution. Many of the largest manufacturers of artificial silk and similar products find that this method of bleaching gives the best results. Weak chlorine solutions electrically produced are used in many large laundries. It is also possible to purify sewage by causing it to flow slowly between electrodes, the slightly saline liquid decomposed by the current producing free chlorine, which deodorises the sewage and destroys the dangerous organic matter present. Electrolytic action has recently been tried in hastening the process of tanning leather. By an electrolytic method the time is reduced from several months to about six weeks, without any deterioration in the quality of the finished product.

SILVANUS P. THOMPSON

Ascending and Descending the Scale. Consecutive Phrases. The Seven Intervals. Chords. The Pedals. Ear Training.

HARP PRACTICE

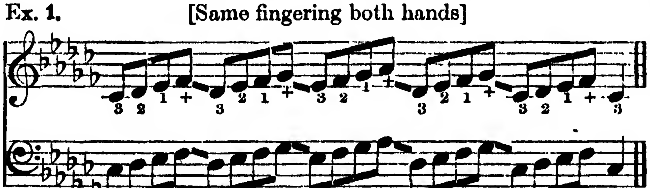
It is the dropping of water which wears away stone. To accustom the fingers, little by little, and gradually, in a way perhaps imperceptible, to do their work with the least possible arm or wrist motion, the student, day by day, should practise Exercise 1, ascending the scale one note at a time. After completing each group of four notes, use special care to get the fingers ready for the fifth note. Try the right hand first. Keep the first and second fingers down. Then try the left hand.

Reversing the Order. Mindful that the endeavour must be to prevent and restrain the fingers from falling into errors which a good master would check, the self-trainer cannot be too heedful in preparing the first finger while the thumb strikes the first note; the second finger when the first finger strikes; the third, when the second produces the sound; the thumb, when the third finger strikes, and so on. Try Exercise 2 with both hands, keeping the thumbs well up.

Now attempt the scale, playing two instead of four notes at a time. Here a fresh difficulty presents itself. The beginner will find the manipulation of four successive strings easier than striking two and two evenly, while keeping the thumbs up close to the right string, at the same time that the third and second, and afterwards second and first, prepare themselves to strike. The strings must be struck with both hands simultaneously. Avoid the rat-tat effect of a postman's knock [Ex. 3].

Hitherto the hand has been preserved in one position. This has now to be changed. Take, for instance, the scale of C. As before, play C, D, E with the third, second, and first fingers. Strike the fourth note, F, with the thumb; at the same time, however, pass the third finger under—below the thumb—to the fifth note, G. Get the second finger into position for the A while the G is struck. When the second strikes the A, prepare the first for the B. Get the thumb ready for C when the first strikes the B. In this manner the successive eight notes are played without interruption or break in the middle part. In changing the position of the hand, take care to bring the third finger down low enough to enable the second and first to get into their right places without undue effort. Bear in mind that, during this change of position, movement of the wrist or arm must be guarded against. The left-hand fingering must be carried out in the same way an octave lower down the scale. Practise each hand separately. Try to strike the strings with equal clearness and strength. When independent facility has been acquired, practise the ascending scale with both hands together in the manner shown in Exercise 4.

Ex. 1. [Same fingering both hands]

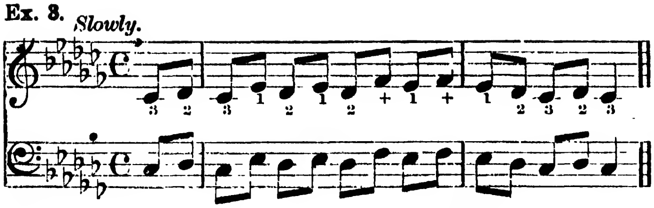


Ex. 2.

In descending the scale, prepare the first finger for B, beginning with the thumb on the upper C. As the first finger strikes, get the second into position for A. Sound the A whilst the third gets ready for G. Now, as the third finger strikes, pass the thumb not under, but over it, so that it drops on F. When the thumb sounds F, the first finger goes on E. As E is played the second finger is prepared for D. The third finger gets into position on the C as the D is struck. Uniform regularity of effect must be aimed at. If the student takes pains at the beginning, this double-action of fingering, or silent preparation concurrently with the production of sound, will be done instinctively. In every respect the motions for the left hand are collateral with those of the right. Exercise each hand separately. Then descend the scale in simultaneous octaves [Ex. 5].

Mastering the Gamut. It is only by constant repetition and concentration of purpose that the student can count upon playing up and down the scale so that the notes flow evenly with progressive velocity. The advance made may often appear imperceptible, but can be tested by going back to the first exercise. Always bear in mind that harp playing is an accomplishment. The ability to induce the fingers to strike the strings freely will surely come with

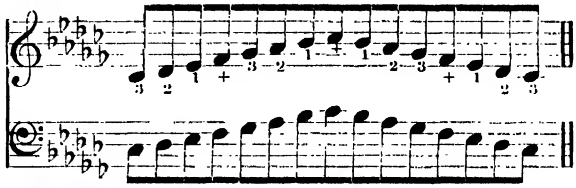
Ex. 3.



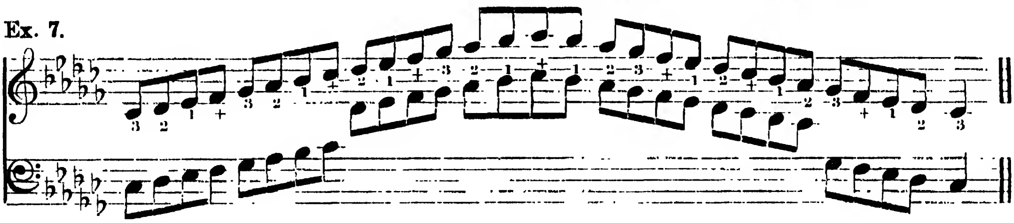
Ex. 4.

Ex. 5.

Ex. 6.



Ex. 7.



practice. An hour's exercise every day will achieve wonders. But it must be regular practice. The student must determine not merely to twang the strings like an uncultured street player. He must endeavour, rather, to attain to an elegant manner of performance, so that, later on, his harping may appeal to musicians of refinement and win for him a position in an orchestra or on the concert platform. But, because unable to have the help of a qualified professor, he must employ extra pains to surmount the preliminary drudgery which every harpist experiences before excelling. Ocular and oral demonstration may be a good thing, yet it is not always a necessity. Too much of it may enfeeble. Sooner or later self-help always becomes essential for the musician. If he is to rise above his fellows, he must rely on his own ability.

Exercise 6 gives the scale, alternately up and down. Attack each note slowly at first, and increase the speed gradually. Practise with a metronome. Before long there will be no need to think about each auxiliary finger movement. Unconsciously to the player the fingers will prepare themselves.

Increasing the Range. Having within the compass of one octave made fair progress in ascending and descending the scale, the next task to deal with is to acquire facility in running up and down two consecutive octaves. The effect should be to play as smoothly as possible. Therefore, do not hurry over the exercise, and particularly avoid striking the strings in a spasmodic manner. Three changes of position must now be mastered. Beginning at the fourth red C string from the treble end of the harp, the third finger of the right hand, as before, plays the note while the second prepares itself for D. After this, when the D is struck, the first makes ready for E. When the E is sounded the thumb adjusts itself for F. It is here that the first change occurs, in the third finger passing under for G. But this has been learnt already. As the G is struck, the second finger predisposes itself for A. As the A is struck, the first finger prepares itself for B. Now, on the B being sounded, the thumb gets into position for the second change. According to the player's hand, the fingering at this point may differ. Bochsa taught that the third finger (followed by the second, first, and thumb) should again be brought under, as after the first change.

Chatterton, however, in the fingering of a scale which is before us, recommends, in preference, that the second finger should be brought under for D, while the thumb strikes the C. Then, as the second strikes the D, the first is prepared for E. As the E is sounded, the thumb is got ready for F. When F is struck, the third is prepared for G. Therefore, according to the fingering employed, the third change occurs either between G and A (Bochsa) or F and G (Chatterton), the second, first, and thumb being used for the top A, B, and C. But the fingering adopted for one hand must be adhered to in the other. The rule is, when going up the scale, that the finger changes are done under the thumb, whilst, in returning down the scale, they are made over the thumb. In the same way that the single octave was practised until it became easy and familiar, the student should now repeat the scale throughout a range of two octaves. Persevere with it from day to day until it ripples up and down without effort, and increases or diminishes in tone from *pp* to *ff*.

It is easy to twang a scale badly and unevenly; to play it smoothly and well is difficult; to play

Ex. 8.

Ex. 9.

it "perfectly" is impossible. That is why the oldest as well as the youngest students should strive to train their fingers by diligent repetition of this exercise, hoping to arrive at a degree of excellence hitherto unattained. "Transcendental technique," however, is only approached by the harpist realising his own faults and then striving to overcome them. The student should always have in his mind the highest ideals. This will be a great stimulus to him in his endeavours to conquer the digital troubles he may at first find in the range of notes given in Ex. 7.

Consecutive Eight-note Phrases. Having obtained comparative proficiency in the two-octave scale, after playing eight notes, go back six. Begin again on the third note. This will give exercise for preparing the third finger to find the E below quickly and accurately while the thumb strikes the C above. After starting afresh on the E, when the thumb arrives at the octave E above let the third finger in the same way prepare itself to fall unerringly on the G below. A fresh group of eight notes is then played up to the G [Ex. 8].

Reverse the operation in descending. Beginning from the top G, when the third finger arrives on the G below bring the thumb over to E, the third note from the top of the scale. Play the octave downwards. When the third finger arrives on the E pass the thumb over and back to the C above. Then play down the octave till the third finger arrives at the starting-point. Without the practical example of a master, the student must give particular care that there is no unevenness during the changes of position. With a teacher to observe and listen to, progress is mainly due to the faculty of imitation. To such an extent is this carried that objectionable mannerisms, characteristic of certain otherwise great players, are emphasised and made doubly ludicrous in pupils. Fortunately for the student, every genuine lover of music has, born in his brain, a consummate conception, or mental model, to which, if he is conscientious, he will strive to attain. This summit of ambition, which beckons on those who strive, was called by Napoleon his lucky star. Let the student steadfastly endeavour to be worthy of his lucky star. [Ex. 9.]

The Seven Intervals. The student should now learn to play the seven intervals of an octave. Practise first with the right, then with the left hand, and then with both hands together. Beginning with middle C, when the first finger strikes the string the thumb should be in its place for sounding the D. As the D is struck the first finger prepares itself to sound again the C. On this note being repeated the thumb places itself in readiness for E. As the E is struck the first finger again goes back to the C. When the C is sounded for the third time the thumb places itself in readiness for F. These six notes should be played smoothly, as if they were slurred. They comprise the intervals of a second, third, and fourth. The player proceeds now to sound intervals of a fifth and sixth. Let the second finger strike the C. At the same time prepare the thumb for the G above. When the G is struck pass back the second finger in readiness to repeat the C. As this string is struck get the thumb into position to sound the A. These four notes must be played smoothly. Advance to the intervals of the seventh and octave. The third finger now strikes the bottom C. As it does so place the thumb in readiness to sound the B above. When the B is struck prepare the third finger to repeat the C. As the C sounds a second time adjust the thumb for the octave C above. These notes, if read backwards, give the same passage descending. For this, prepare the fingers carefully in the reverse order [Ex. 10].

Ex. 10.

Ex. 11.

Two Notes with Each Hand. Hitherto the student has confined his attention to striking the strings in succession with each hand. This is peculiarly characteristic of that instrument which has given to music the term "arpeggio." In English it means "in the style of a harp," and denotes a sequence of sounds which, together, form a chord.

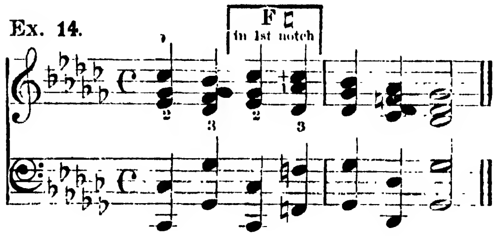
A chord, then, is produced by sounds played simultaneously. On the harp it is easier to strike strings singly with each hand than to strike two or more of them together. But when the performer has mastered the playing of chords, the effect of his instrument is considerably enhanced. Now, the beauty of chord playing depends on the recoil, or elasticity, of the fingers independently of the wrist and arm; therefore, keep the hand perfectly steady. Let the thumb, after every note, return to its perpendicular position. Take special pains with the left hand. Unlike the right, it has no support from the body of the instrument. Using the last exercise as a groundwork for the next, instead of playing the notes singly, couple each pair together. Endeavour to play the intervals equally, both as regards strength and speed. Sound them slowly and softly at first. By degrees, increase the force and celerity of performance [Ex. 11].

Ex. 12.

The Full Chord. The student will now attempt to acquire the ability to strike four notes in combination. Place the three fingers and the thumb on the strings together. Put the third on the bottom C, the second on the E above, the first on the G, and the thumb on the octave C. Round the fingers gracefully. Keep the thumb well up, and rest the arm on the soundboard just above the wrist-joint. Having thus prepared the chord, strike the strings by causing the fingers to spring elastically towards the palm of the hand. Immediately the thumb falls, it must get back to the erect position. Although, after striking, the fingers and thumb quit the strings, neither the hand nor wrist must move.

Ex. 13.

Ex. 14.



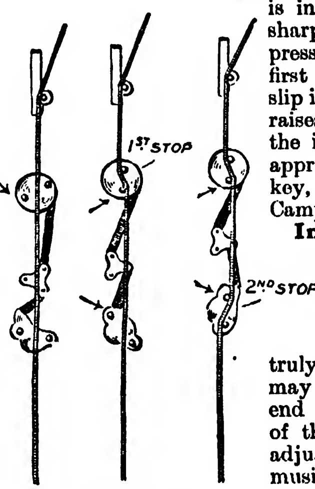
A point to note is this. Although the sounds in a chord on the harp are supposed to be produced simultaneously, they are actually struck in quick succession from the lowest to the highest note. This is more effective than firing them off together. Why? Because the higher the note, the quicker and shorter is the vibration of the string. If, therefore, the shortest strings are struck last, the chord dies away equally. Be careful to strike the strings with the sides of the fingers. Vibration is marred if the nails touch the strings. Owing to lack of support from the soundboard, the left hand will require to be exercised with extra care. Its movements should be identical with those of the right. Confine the motions to the fingers, and keep the arms steady [Ex. 12].

A valuable exercise is to play the chord notes successively. Keep the hand in the same position as when striking a chord, and sound the notes slowly and consecutively. After the fourth is struck, see that the thumb is kept well up in its proper place. The natural tendency is for it to sink. This propensity must be overcome. It is a bad habit easily contracted [Ex. 13].

The Pedals. On the harp, all naturals and sharps are produced by the pedals [1]. There are seven of these, like the seven senses, one for

Ex. 15

each note of the scale. In China each separate sound has a distinctive mental meaning. This septet of pedals is appropriately situated in the pedestal of the harp. Four of the levers are on the right, three are on the left of the player. Beginning from the centre, the right foot negotiates the E, F, G, and A♭ pedals. The nearest on the left is the B♭. Then follow, for the left foot, the C and E♭ pedals. Each slot in the pedestal is furnished with two notches. Put the toe on the left middle pedal, C♭, the harp being tuned in this key. If the lever is pressed down to the first notch, a rod in the column is raised. This operates on the metal comb or action in the neck, and puts greater tension on all the C♭ strings by stopping off a portion of their length, as the violinist's finger does on the fingerboard of the fiddle. The pitch is thus raised uniformly a semitone to C♮. Depress the pedal to the second, or lower, notch. The leverage action now raises the pitch another half-tone, and transposes all the C strings to C♯. In consequence, when certain other pedals have been depressed, there is no more difficulty in playing on the harp in the key of C♯ than in any other, although a beginner on the piano would find that key, with its six accidentals, or the natural harp scale with its seven flats, most embarrassing.



1. HARP PEDALS

Take the second pedal from the right, F♭. Lower it to the first notch. This raises all the F♭ strings to F♮. On the piano, the key of F♭, with its eight accidentals, is most bewildering, whereas the key of F♮, with only one flat, is quite easy. On the harp, one is as simple as the other. Now depress the pedal to the second notch. This raises all the F strings to F♯. On the piano, the key of F♯, with six accidentals in its signature, necessitates the employment of many black notes. Consequently, the fingering for both hands differs from what it would be in F♮. But the harp player, having put down the necessary pedal, adheres to the same fingering, whether he plays in a key with eight flats, one flat, or six sharps.

Ear Training. Hitherto, for the purpose of practising, all the pedals have been up. The harp, therefore, has been in its natural key of C♭, a semitone lower than the natural key of the piano. This is as well. It does not diminish their vibrating length, and gives greater resonance to the instrument. But as soon as the fingers have been drilled to do fairly well what is required of them, the ear must be trained to accustom itself to recognise changes of key. This is done by employing the pedals. Now depress all the pedals quickly one notch. What is the result? The pitch of all the strings is raised equally half a tone. The harp is, therefore, no longer in the key of C♭, with seven flats. Why? Because all the flats have disappeared. Therefore, it is now in the scale of C♮, and the pitch of the harp corresponds with the piano if the student plays his exercises on the latter instrument without regard to the flats in the signature of the music.

The natural scale of the Highland bagpipes is in the key of G, which has one sharp, F. To interpolate this sharp, press down the F♭ pedal (now in the first notch, and therefore F♮) and slip it into the bottom notch. This raises every blue string throughout the instrument to F♯. It will be appropriate to try, in this bagpipe key, the melody known as "The Campbells are Coming" [Ex. 15].

Insertion of Accidentals by Pedals. Accurate and rapid management of the pedals is an important art with which the student cannot become too familiar. In a truly diatonic melody, a piece may be played from beginning to end without manipulation of any of the levers after they have been adjusted at the start. In modern harp music, however, modulations of harmony into different keys frequently occur several times during the performance of a single piece. This necessitates on the part of the player an ability to press down, noiselessly, the correct pedal at the right moment.

Now put up all the pedals again. We give an exercise in which a modulation from the key of C♭ to G♭ occurs [Ex. 14]. Strike the first three chords in the natural key of the harp. To obtain the necessary F naturals in the four chords which follow, depress the middle right pedal to the first notch. This raises all the blue strings half a tone to F♮. Practise the exercise slowly with a metronome until the pedal change is made without retarding the time. Then gradually increase the speed until this key change becomes automatic.

ALGERNON ROSE

A dictionary of the Technical Terms and Phrases in Music appeared on page 1823

The Making and Finishing of Hosiery Goods. Lace, Plain and Fancy. Embroidery. The Cloth Warehouse.

HOSIERY AND LACE

The fundamental difference between weaving and knitting is the same as between darning and knitting. The mender of stockings works upon two sets of threads, crossing and recrossing under and over until the two sets are firmly united. The hand-knitter of stockings forms loop after loop out of a single thread, and her work can all be undone and reduced to one thread again by pulling upon a broken loop. To get a clear understanding of the operations of machine knitting it is desirable to follow the movements of a hand-knitter. By the use of one plain needle a row of loops are "cast on" another needle until there are enough for the width of the article. The first row of loops is the starting point of a further row, and as the new loop is made the old one is "knocked over" the needle point, so linking the two together. Machine knitting follows the same process of looping and knocking over, but the machine, instead of making loops one at a time, makes a number, or a whole course, of loops at once across the width of the fabric, and thereby works quickly. The feat is done by providing one needle for each loop, with auxiliaries for traversing the yarn across the needle, and for looping and knocking over the stitches.

Lee's Frame. The system of knitting a flat web, which may afterwards be formed into the round by sewing together the edges of the fabric, can best be appreciated by reference to the original frame invented in the sixteenth century by William Lee. Lee began his machine [1] by making a set of needles (*i*) inserted in a bar of wood. The needles were of spring wire, curved back to form a barb, and the shank was recessed or grooved below the curved point of the beard. Using a set of such needles he succeeded in forming loops of yarn between them, and in knocking over the stitches by hand. In making a frame to do the work mechanically, Lee fitted above his needles a set of pivoted arms or *jacks* (*h*) carrying thin nose-shaped pieces of metal (*j*) called jack *sinkers*, to pass between each pair of needles, and to serve to press down the yarn in waves. The jacks were held in position by the springs (*k*), and were tilted by the lateral movement of the *slur-cock* (*m*) carried on the slur-bar (l).

Framework Knitting. A thread of yarn having been laid across the needles, the tails of the jacks were lifted by the slur-cock, with the effect of bringing the sinkers forward and downward. The yarn was laid in curves or loops over each needle, and the thread was thrust under the barbs close to the needle heads. A presser bar, not shown in the illustration, descended and closed the barbs by pressing their points into the groove. At this stage the row of loops last formed was advanced by the sinkers and pushed over the closed hook and over the end of the needle, one row of loops thus being interlaced with the other [2]. Finally, the machine took the formed loops back along the stems of the needle, in readiness for making a new course.

Improvements, permitting the use of more needles within a given space, and allowing of a greater variety of stitches, were added to Lee's machine. A *tuck presser* enabled the production of fancy effects by allowing chosen needles to accumulate more than one stitch before knocking over. The *Derby rib* motion was added, whereby more elastic ribbed hosiery could be made by knitting loops *plain* or *purl*, the difference between which kinds of stitches consists simply in the reversed direction of knocking over. *Ticklers* were added, also enabling the fabric to be narrowed or widened at will. These machines of the old framework knitters are obsolete, but they illustrate in a simple manner the principle upon which machine-knitting is done.

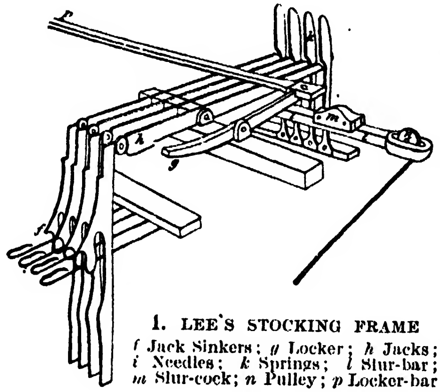
Warp Knitting. In the original knitting machine the loops were formed all out of one thread, and the courses of loops ran along the width of the fabric. In the *warp* knitting loom, introduced at a much later date, a number of threads were provided equal to the number of loops to be formed in the width. The loops, instead of following each other sideways, followed lengthwise in succession, those of one thread being interlinked with its neighbour, as in crochet. The system is of advantage in making striped goods by the use of yarn of two or more colours, and in making openwork. Hand warp looms are at work still in making small fancy goods, and the principle has been adopted upon various power machines.

Cotton's Machine. About the middle of last century a machine with jacks, sinkers, and slur-cock was introduced to knit flat web and tubular fabrics by power. Improvements upon it enabled small tubes to be woven for stockings, and auxiliary hand apparatus allowed these to be fashioned or narrowed and widened to fit the leg, heel, and foot; and later the fashioning was made automatic. The most revolutionary change was caused by the advent in 1868 of William Cotton's machine for enabling one operative to turn out seventy dozen pairs of hose a day, and cutting down the cost of making from twenty-nine pence a dozen to fourpence. Cotton set the needles of the machine upright instead of horizontally as hitherto, and imparted motion to them, making them work up and down and in and out. The sinkers were placed horizontally, and the presser was made stationary. The narrowing of the fabric was effected by cams, and placed under the control of toothed wheels, and the machines were made with from six to twelve separate knitting heads. With the addition of the subsequent improvements that have been put upon this machine, nearly every kind of plain or ornamental fabric can be knitted upon it, and by the aid of a jacquard or dobby attachment a large number of fancy effects can be obtained.

Latch Needles. The highest class of hosiery still requires the use of bearded needles, but about sixty years ago the *latch* needle was introduced by a Leicester man. In this needle the spring beard is replaced by a latch or tumbler, actuated by the stitch and pivoted in a slot upon the shank. The latch dispenses with sinkers, and has enabled the needles to be set more closely together. The invention of the latch has permitted stockings to be

knitted seamlessly in endless lengths. The different kinds of ribbing in the leg, the narrowing of the calf, the fashioning of the heel, and the shaping of the foot all proceed continuously in due order. The fabric knitted is wound upon a roller as it is produced, and all that is needed to complete the articles is to cut the threads at the joining of the toes of successive stockings, and to link these loops together by sewing.

Hand Machines. The needles are arranged vertically in a latch machine made in England, and much used by knitters working in their own homes. The needles are arranged in grooves around a cylinder, and as the needle is raised the stitch made last is slipped below the latch. The yarn is received in the hook of the needle, and as the needle descends the latch is closed by the old stitch, and the new yarn makes the new loop. The guide which supplies the yarn and the cams which control the movements of the needles revolve, and so does the fabric, which is drawn off and wrapped round a roller. The machine has a number of yarn guides and of cams equal to the number of courses made at each revolution. In an alternative type known as the hand *flat knitting machine*, adaptable to work either flat web or tubular fabric, there are two beds of needles inclined toward each other at an angle of some 90 degrees.



1. LEE'S STOCKING FRAME

f Jack Sinkers; *g* Locker; *h* Jacks; *i* Needles; *k* Springs; *l* Slur-bar; *m* Slur-cock; *n* Pulley; *p* Locker-bar

Rotary Machines. The *English* loop wheel-machines, extensively used for making tubular fabrics of diameters ranging from two or three inches up to two or three feet, have vertical bearded needles, disposed in a circle with their beards pointing outwards. The needles, the fabric, and the coiling apparatus revolve as the work proceeds, the yarn guides remaining stationary. In the *Continental* circular machine, the bearded needles are horizontal, and set with their heads radiating from a centre.

The Hosiery Factory. Apart from differences of broad principle there are endless differences in the capacity of the machines and in their degree of automatism. It is not practicable to make as many changes upon a knitting machine as can be made upon a loom, and special machines are reserved for each special purpose. Attachments are added to simple machines for *plaiting* or introducing an extra thread of silk to lie on the face of the fabric, or extra wool to form a fleecy back, or for making an extra splicing or thickness, or for changing the colour of the yarn at the heel and toe, or for making openwork fronts or openwork all round the leg, or for striping in a number of colours. The demand for striped, checked, and fancy hose is always growing, and it is possible to turn these out complete by the use of special machines.

2. LOOPING ON NEEDLES

R Loops of single thread; *S* Loops of web to pass over beards

Special machines are made for knitting ribbed tops endlessly, to be cut later and sewn upon stockings knitted upon the *half-fashioning* machines. Embroidering machines are kept for embroidering fancy patterns on hose knitted separately. The rotary machines knitting tubular fabrics of large diameter produce a web that can be cut to form the bodies of skirts, vests, shirts, combinations, and sweaters, which can be completed by joining smaller tubes for the arms or legs.

Separate sizes of machine are kept for knitting ties or mufflers, while some manufacturers have a special plant for knitting the large quantities of ramie yarn for making incandescent mantles, or the larger quantities of cotton yarn for knitting into tubes for shrouding carcases of refrigerated meat. Garters, knee-caps, surgical bandages, gloves, coats, shawls, cardigan jackets, and jerseys are a few out of the myriad articles now made by knitting one class of yarn or another.

Hosiery Goods. The cutting, joining, and trimming of knitted web calls for a whole plant of machines in itself. Power shears are used for cutting, and a large number of varieties of sewing machines for linking, whipping, seaming, and buttonholing. After being completed, the garments are scoured in automatic washing or dollying machines. Some of them have to be *fulled* by being hammered in the fulling-mill to open the twist of the yarn and cause some degree of felting to take place between the fibres. The garments are dried in centrifugal hydro-extractors or in hot air chambers. They are pressed between steam-heated plates or calendered between heated cylinders. Some garments require to be stretched on wire or wooden frames to preserve the shape and to correct unequal shrinkage, and some fabrics have to be passed under rotary brushes to raise a fleecy pile upon the face or back of the fabric.

Hosiery articles are made from a large variety of yarns—worsted, woollen, mixed woollen, cotton, and silk. *Botany* worsted is used for the finest articles, and *crossbred* or English quality of worsted for the cheaper. What is called *merino* hosiery is made from a yarn spun of mixed woollen and cotton, and the so-called *lamb's wool* is a heavy woollen yarn often spun from short fibre. The *lisle* thread used for gloves and stockings is an especially hard twisted cotton yarn. Both *organzin* and *spun* silk are employed for knitting, sometimes as a sole material and in other cases in company with worsted.

In general, a high degree of uniformity is required in yarn intended for knitting, as imperfections are more difficult to disguise than in woven goods. Except in special instances a rather bulky thread is preferred, with fewer turns of twist in the inch than in yarns meant for weaving.

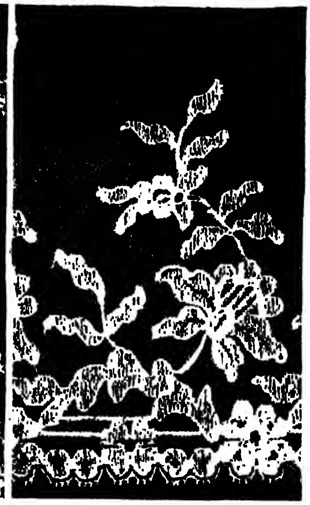
LACE

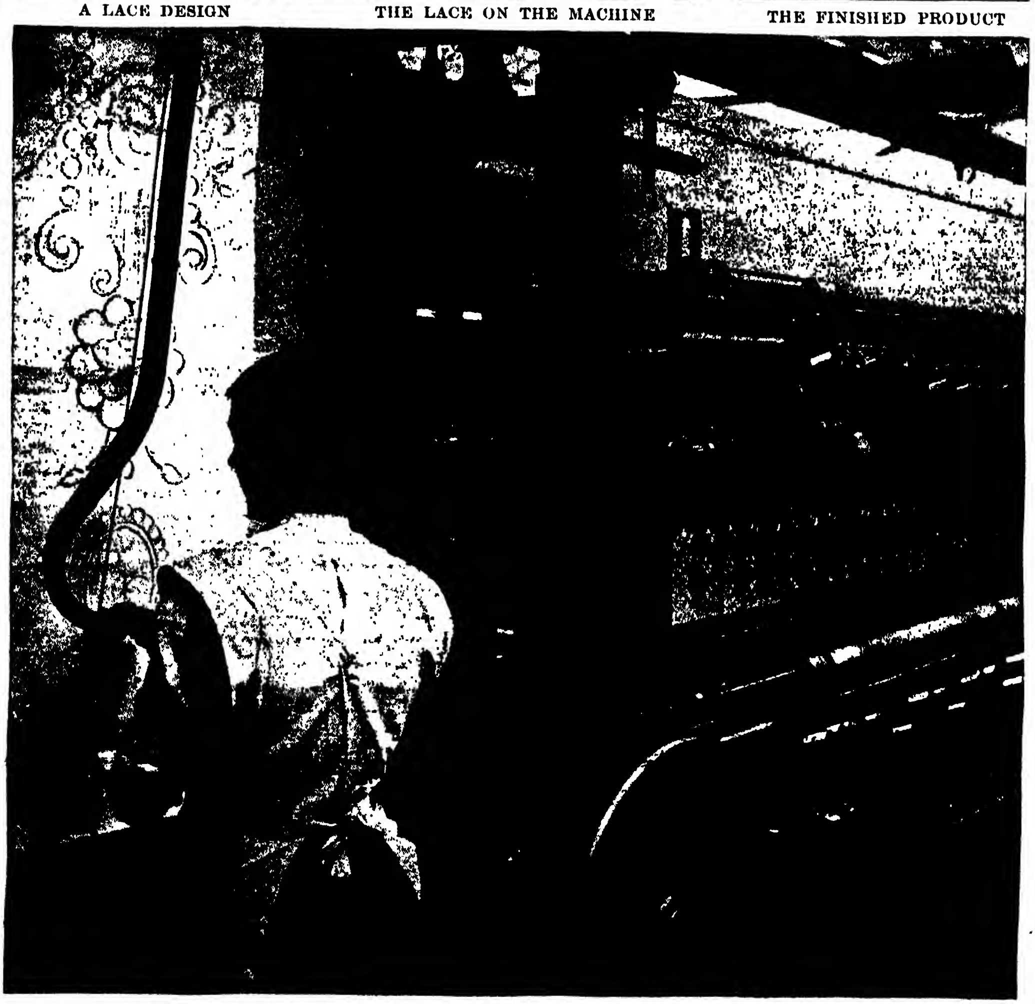
In its simplest form, a lace is a string or cord, such as a boot-lace; and a lace fabric, in the strict sense, is one formed more or less ornamentally, by the twisting of cords one around another. Hand-made lace is properly of two kinds, although the two forms

THE WONDER OF A MODERN LACE MACHINE


A LACE DESIGN

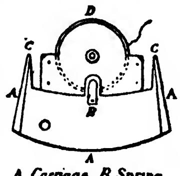

THE LACE ON THE MACHINE


THE FINISHED PRODUCT


TRACING A PATTERN WITH A PANTAGRAPH ARM TO TRANSFER THE DESIGN ON THE FOUNDATION

are often found in combination. There is *needle-point* lace, worked with needle and thread; and *pillow lace*, worked by twisting and intertwining threads which are passed around pins placed upright in a hard pillow or cushion. Pillow lace is made with the aid of a number of small bone bobbins carrying the supply of thread.

Plain Net. Lace is a loose fabric, and the first laces to be made by machine were manufactured upon Lee's knitting frame by a manipulation which allowed needles to form open spaces in regular order. By alternating the empty spaces, a net-like fabric was formed, capable of being further ornamented by the needle. Net or mesh is the elementary form of lace fabric, and a perfectly hexagonal machine-made small net, imitating that formed upon the lace-maker's pillow, was not made until Heathcoat introduced his bobbin-net machine in 1809. Copying the example of the pillow lace maker, Heathcoat arranged half his threads as warp or *beam*, and distributed the other half on small bobbins as weft. He devised a machine, which in its own day was the most complex that had ever been invented, for twisting the beam and bobbin threads into a sort of trellis [5 and 6.] With modifications rather of detail than of principle, the machine is the same that is in use to make English nets today.



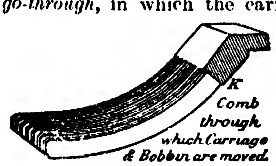
3. BOBBIN AND CARRIAGE OF HEATHCOAT'S NET LOOM

The principal features of the plain net machine are two roller beams placed above one another, the lower carrying the warp and the upper receiving the cloth. There are thread guides dividing the warp into alternate threads, and serving a purpose resembling that of healds in the weaver's loom. Each thread of weft yarn is carried in its own bobbin, a neat little metal one occupying the very minimum of room, and consisting of two flat metal ends connected by a very short spindle. The bobbin is fitted accurately upon a carriage [3] made from thin brass plate, and is held in its place by a spring. The carriage is fitted with catches [C] to fit the catch bars of the curved comb [4]. The ends of the threads on the bobbins are attached to the upper beam, and when motion is imparted to the carriage by the *shifting bars* the bobbins swing pendulum-fashion between the warp threads. One half the bobbins are set before the warp, and one half behind, and there are combs on each side to receive the swinging bobbins. The accepting comb is given a traverse equal to the space of two warp threads. Half the bobbins are traversed to the left and half to the right, under the influence of the point bars; and the effect of moving the two sets of threads relatively to each other, and of passing one set around the other, is to tie them into the form of a regular mesh.

Levers' Lace. The principle of making plain net was incorporated by Levers in designing the typical Nottingham lace machine for the production of laces in fancy patterns. The salient difference lies in the arrangement for holding the warp. In the plain net machine the take-up is equal throughout the width. In fancy lace making, different lengths are required for the several threads, and the warp is carried upon small beams ranged one above another. The threads of warp are led upward through a comb and over a cylinder on which the fabric is automatically wound. Bobbins, often so small that thirty can work together in one inch, are employed, and these swing between and round the warp. The varying tensions on the several warp threads have their effect upon the design, for it is the slacker of two threads which twists itself around the other when oscillation is imparted. When the warp is slackly held and the bobbin or weft thread is tight, the warp winds around the weft, whereas when the weft is the slacker the contrary takes place. The sideways shift needed to form net is spoken of as *gaiting* or *shogging*, and in making fancy lace it is necessary that the gaitings should be irregular, and that certain warp threads should be stationary while others move. Simple designs can be made by the to and fro motion of the bobbin and the shogging of certain threads of warp, and these movements can be controlled by cams, corresponding to the tappets of the weaving loom.

The Lace Jacquard. Effects of more irregularity are obtained by jacquard cards and cylinders [p. 2095], which are used to control the rods actuating the bobbins and carriages, so that some may be moved while the others are at rest. The threads of warp pass through the eyes of guide bars, and by the aid of a separate jacquard these threads can be moved to right or left. It is on such machines that the standard Nottingham laces and curtains are made, and satisfactory machines of the kind have never been built outside this country. The accuracy of workmanship acquired in machines working upon from 12,000 to 30,000 threads, with from ten to thirty bobbins to the inch, and making eighty to a hundred movements a minute, can perhaps be appreciated.

Lace and Curtains. The two general types of fancy lace machine are distinguished as the Levers' *lean-bars*, in which the swinging bobbins are landed on brass sliding bars; and the Levers' *go-through*, in which the carriage works into the combs without these guides. The *curtain* machine is an especially wide one, and made to take work up to 440 inches, and it works with four sets of threads—bobbin, warp, spool, and extra-beam. For making thick, flat, heavy laces, such as are used for cheap edgings, there are three kinds of *crochet* machines in use—the *fast warp* for making nets, the steel bar or *fast tatting*, and the *plain crochet*.

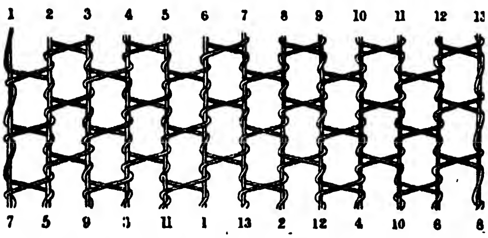


4. SECTION OF COMB BAR

In fancy lace it is usual to use threads of different thickness for the bobbin, the ground warp, the outlines, and the gimp. The fineness of fancy lace is measured by number of points to the inch, of which usually there are between nine and sixteen, signifying that the lace has been made with double that number of bobbins. Fancy lace is manufactured in narrow strips, and as many strips are made at once as the machine will take, so that one set of movements is made as productive as possible. Lace is measured by the yard or by the *rack* of 240 consecutive *meshes*, and it is by the rack that the operatives are paid.

Embroidery. The plain net fabric as made by Heathcoat becomes the basis of embroideries, and large quantities of Nottingham net are exported to Plauen to be embroidered up Con tinental machines. The embroidering is done to

some extent in this country upon machines embroidering considerable widths of net at one time in patterns which are traced with a *pantagraph* arm, from a design in front of the operative. Ingenious kinds of lace are made also by embroidering in cotton upon fine silk or wool foundations; and when the supporting fabric has been dissolved away by alkalies, which destroy animal fibre without materially affecting the vegetable fibre [p. 1426], there is nothing to show how the effect has been got. Embroidering machines are fitted with attachments for piercing fabric with



5. BOBBIN NET AS SEEN IN THE LOOM

holes of varying size and shape and for stitching around the edges; but a clear distinction has to be drawn between embroidery and true lace.

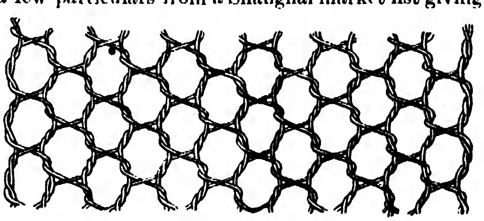
The Cloth Warehouse. The last of the processes which piece goods undergo before being sent into consumption are not the least important of the long series of operations, although they are the work of the warehouse rather than of the mill. In some rare cases cloth is sold by weight, or upon the basis of the length of the warp, but normally it is sold by measure. In olden days it was measured yard by yard with the stick, and the statutes of 400 years ago ordained that it should be sold thus only, with the addition of one inch to every yard. Hence comes the custom general in the woollen trade, and partly so in the worsted and linen trade, of selling cloth by 37-inch measure. The cotton trade has a *long-stick* measure of 36½ inches as well as the *short stick* of 36 inches to the yard. However, measuring-sticks are only used in cutting off short or pattern lengths, and the habit of measuring by pulling cloth over a five-yard table and marking each successive length, is giving way before the use of measuring machines.

Measuring. Measuring is done incidentally while the cloth is being *rolled* or *blocked*, or being plaited or *cuttled* into folds. Heavy woollen goods are rolled by hand, the cloth being wrapped around a flat board. The work is done at a long table with a polished top, and some practice is required before the piece can be rolled with its edges perfectly even. Measuring can be done simultaneously by the use of a simple T-shaped apparatus for conducting printed paper tape from a coil to the cloth. The tape is printed in yards and inches, or in metres and centimetres, and the zero mark is left showing next to the rolling board. The tape system has one great advantage in the avoidance of dispute, and another in the fact that the tape can always be relied on to tell how much cloth is left in a piece or *bolt* from which lengths may have been cut since its first appearance.

Making up Piece Goods. Light-weight goods are rolled upon boards by machine, and are measured, not always with the utmost accuracy, by carrying round a friction drum of known diameter, geared to which is a dial and index showing the total yardage in the piece. A more expensive machine inserts at determined intervals numbered brass clips upon the selvedge. Large quantities of cloth are delivered not in rolls but in folds, and in some places folding or cuttling is done manually. The bulk of the work is done by a machine fitted with knives working back and forth through an arc of a circle, to lay the cloth in regular folds of a length that can be regulated at will, and at the same time measure it. The piece being laid in flat folds, it is usual to wrap around it as many yards from its own folds as are required to hold the whole together and enable it to be lifted, and the selvedges of the folds are, in some cases, stitched with string as an additional safeguard. The piece is furnished with a swing ticket or label upon which its number, quality, length, and other identifying marks are entered, and it is then parcelled in paper.

Marking for Export. In the case of some goods for export, the *making up* in folds and coloured papers is elaborately done. Fancy *headings* of brightly coloured cloth are stitched on, or gilt letters and devices are fastened down with a hot iron. Still more often, goods for export are decorated with trade-marks, and white and unbleached cottons are treated with large stamps upon the face-plait, or outer fold, setting forth the full particulars of their quality, length, and origin in coloured inks.

Trade-marks are of the utmost consequence in the export trade in cotton, and over 80,000 marks are known to be in use in the Manchester trade. Some are registered, but more of them are unregisterable, and to Asiatic dealers and peasants these marks symbolise the quality of goods that they know, and an unsatisfactory delivery of goods under a mark is enough to throw the *chop* out of use for years. Some idea of the nature of the chops used in the China market can be got from a few particulars from a Shanghai market list giving


6. FINISHED BOBBIN-NET

the names under which some favourite devices are known.

SOME NAMES FOR GREY SHIRTINGS

10 lb. Painted Crab.	12 lb. Double Ladder & Gun.
11 lb. Boy and Zebra.	12 lb. Soldier G G G.
12 lb. Chinese Volunteer.	10 lb. 2 Handsome Ladies.
7 lb. 3 Students.	10¾ lb. Rich Man.
8 lb. 9 Sons.	10¾ lb. Chin Chin New Year.

The making up and the subsequent packing of piece goods in bales and cases is an industry to itself in Manchester. It employs thousands of men, and several large companies which own great warehouses in which the exporters have their offices and get their goods packed at a charge per piece and per bale. The warehouses are fitted with large hydraulic presses for baling, and such cloth as does not go abroad in bales lined with tarpaulin and bound outside with iron hoops goes largely in tin-lined cases. The goods have to wait sometimes more than a year in humid climates before the packages are opened, and they are soldered in air-tight tin inside wood.

J. A. HUNTER

Non-sedimentary Rocks. The Geological Record of the Earth's Development. The Story of the Strata. Chronology of the Earth.

THE EARTH'S GEOLOGICAL RECORD

In order to complete our survey of the rocks which compose the visible portion of the earth's crust it remains to consider the non-sedimentary rocks, which form a very noticeable, though not by any means the larger, part thereof. These are the igneous rocks which come to the surface in parts where for various reasons the later sedimentary rocks have not been deposited above them, or have been entirely worn away by denuding agencies, leaving the bare, igneous rock cropping out, as in the granite tors of Dartmoor, or in the volcanic sill forming the Salisbury Crags in Edinburgh.

Non-sedimentary Rocks. These igneous rocks, as we have seen, are known as *plutonic* or *volcanic*, according to the manner in which they were originally formed. The plutonic rocks are those which were originally formed deep beneath the surface of the earth, and have since been revealed by the removal of the overlying strata. The volcanic rocks are those which have been brought up to the surface by hypogene activity, and have frequently been arranged in stratified sheets, often alternating with the true strata produced by epigene agencies. Of course, there is no absolute distinction between these two classes of rocks, because the volcanic rocks which appear on the surface must obviously be connected with the plutonic rocks remaining in the subterranean reservoir. But it is usually thought convenient to distinguish between volcanic and plutonic rocks, which, indeed, show somewhat different characteristics.

Plutonic Rocks. The plutonic rocks with which we are here concerned have usually been thrust up from the lower parts of the earth's crust by hydrostatic pressure, have been intruded into other rocks of more ancient formation, but have solidified beneath the surface of the earth, and therefore under considerable pressure. The fluid masses which were thus squeezed upward from the lower or molten parts of the earth's crust naturally took the line of least resistance, and the various shapes into which they expanded depended on the local conditions. We now find them mainly in one of four distinct formations—as *bosses*, or shapeless lumps of rock, often many miles in extent; as *sills*, or flat and roughly horizontal sheets of rock; as *dykes*, or veins of rock which have filled up the cracks or fissures in earlier formations [69]; and as *volcanic necks*, which occupy the pipes and craters of ancient volcanoes.

There are many examples within our own islands of each of these formations. Vast intrusive masses of granite characterise the scenery of Dartmoor and the South-west of Scotland. The Salisbury Crags, beside Arthur's Seat at Edinburgh, consist of a thick sill of dolerite; another forms the rock on which Stirling Castle is built, while the great Whin Sill can be traced for a distance of 80 miles across the North of England. Veins or dykes of intrusive rock are often found on seashores, as at Elie, in Fifeshire, where the wearing down of the softer adjacent rock has left them standing up like walls. The mineral veins in which many ores are found are generally intrusive dykes which have been run into cracks in the older rock. The hardened lava plugs of ancient volcanoes form the conical hills which are so common in the South-east of Scotland, like Arthur's Seat, North Berwick Law, and Largo Law [70].

Volcanic Rocks. Volcanic rocks are distinguished from the plutonic formations by the fact that they are usually found with a kind of false stratification, in which the volcanic *lavas* and *tuffs* are found alternating with true sedimentary beds [68]. It is easily seen how this state of things has come about. Volcanic action is seldom continuous; the eruptions are usually separated by long periods of quiescence. At each period of activity the volcano sends sheets of lava welling out in all directions from the vent. When the flow ceases, these sheets harden into rock. The ordinary atmospheric agents then set to work to cover this sheet of igneous rock with the débris of which we have seen all sedimentary formations to be composed. After this layer has attained a certain thickness, which depends upon the length of time during which the volcanic activity is suspended, a new eruption takes place, and a second sheet of lava covers the sedimentary formation, baking, hardening, and perhaps chemically altering it. Thus in the lapse of ages we get a characteristic piece of *volcanic stratification*, in which sheets of lava alternate with layers of true sedimentary rock. There is a very interesting illustration of such a structure near the mouth of the Severn, which in ancient times was a centre of considerable volcanic activity.

All that was said in a preceding chapter as to the curvature, tilting, crumpling, and dislocation of sedimentary rocks applies equally to igneous formations, which display well-marked examples of joints, faults, and cleavage planes, though the other division into strata, or bedding planes, which characterises the sedimentary rocks, is usually absent, and when present, as in the schists, has been produced by different agencies, generally those of subterranean heat and pressure due to gigantic earth movements.

The Geological Record. We have now taken a general survey of the leading facts of geology. We have inquired into the existing structure and materials of the earth's crust,

and we have examined the agencies which have brought about that structure and modified those materials. It now remains to see to what extent geology is able to trace the past history of the earth through the long ages during which these alterations have been taking place to produce our habitable earth. This record, though full of

68. PILLOW LAVA AT PENTIRE HEAD, CORNWALL

gaps and imperfections, due to our limited opportunities of study, is written deeply upon the rocks, and has been read by geologists with wonderful precision.

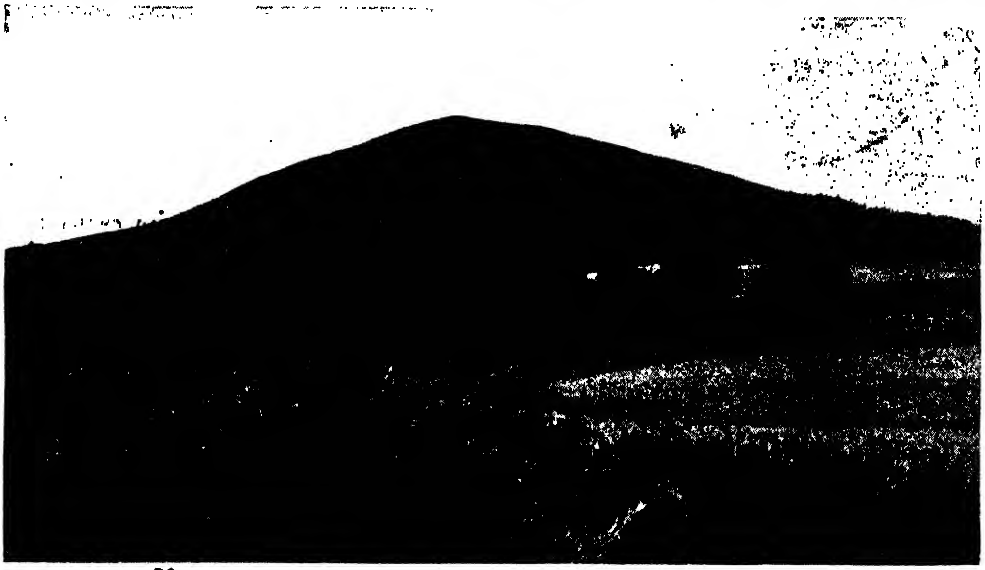
Palæontology. The reader has already seen how the fact that the majority of superficial rocks are arranged in strata enables us to tell their relative age. Where we are dealing purely with sedimentary rocks it is quite clear that the upper strata must be younger than those that lie beneath them, and on the top of which they were originally laid down. There are some apparent exceptions to this rule—as when the strata have been so crumpled as to undergo actual *inversion ;* when the oldest layers have been brought to the top, and might, by a hasty observer, be mistaken for the youngest ; or when a mass of eruptive rock has been intruded into the midst of strata which are all really its superiors in age. To read this wonderful record with ease and accuracy requires the training of a lifetime, but the general results that it has yielded can be briefly explained. This geological record has a very important bearing upon the history of life. We have seen that the strata frequently contain fossil remains of the plants and animals which lived at the time when they were being formed. They naturally share the relative age of the strata which they inhabit, and thus we are able to discover the order in which the various forms of life have appeared upon the earth, and to provide trustworthy materials for the development of the great theory of organic evolution. This part of the subject, known as palæontology, must be studied by the student of biology in the special chapters on that subject. The geologist's share in the matter is confined to expounding the order in which the various forms of life have come into existence.

The Story Told by the Strata. It must not be supposed that the strata which make up the crust of the earth are everywhere arranged in the same order, or that the complete history of the rocks can be learnt by the simple method of boring into the earth at any convenient spot, and tabulating the strata through which the shaft passes. The earth has so long been moulded by the agencies of change, which we have already studied, that the geological record has become extremely complicated, and it has required the labour of more than a century to elucidate its mysteries and entanglements. The work is something like that of the historical student who has to build up the coherent story of his chosen episode from books that he finds in the great national libraries of London, Paris, and St. Petersburg ; dusty documents that he has to spell out in the London Record Office, among the archives of the Vatican, or the Royal Charters of Simancas. So the geologist reads one fragment of his story on the coast of Scotland, another in the gorges of Colorado, another in the mines of the Rand, and yet another in the contorted strata of the Andes. The whole thickness of the rocks that have been built up since the earth's crust first solidified amounts to many miles, and there is no place in the world where the whole vast series is conveniently displayed to the study of man.

The Chains of Geological Evidence. But everywhere the story is the same; and the fragments of knowledge which one geologist has won from his lifelong study of the Scotch granites dovetails in with that which another has obtained among the cañons of America. Everywhere it is found that there is a definite order in which the strata follow one another. There are often gaps and imperfections in the history of the rocks wherever we study them, but the gaps are never quite the same; and the

69. DYKE OF WHITE-TRAP, CUTTING CRUSHED CARBONACEOUS SHALES, ST. MONAN'S SHORE, FIFESHIRE

knowledge which we gain in one locality helps to fill in that which is gained elsewhere. In this way it has been ascertained that there is a definite order of succession among the rocks now visible on the surface of the earth, and that this succession everywhere holds good. Thus, to take a simple instance, we find that the coal measures everywhere overlie the Old Red Sandstone, which is of earlier formation. In any part of the world we may find Old Red Sandstone where coal measures do not exist at all, or, conversely, we may find coal measures without the presence of the Old Red Sandstone. But we can say with certainty that, wherever we find a layer of Old Red Sandstone, it is absolutely useless to bore through it in the hope of finding coal below. The value of such knowledge to the miner will be apparent; and it is never falsified.



70. THE CONE OF AN EXTINCT VOLCANO, LARGO LAW, FIFESHIRE

Chronological Classification of Rocks. The various stratified rocks which have already been described fall into certain series, each of which appears to have been formed at a definite time in the earth's history. Geologists are now pretty well agreed as to the main classification of these series, although there are still points of difference among them when it comes to minute detail. They all divide the rocks into five main divisions, each of which corresponds to a chronological epoch.

The oldest rocks of all, which were first formed when the crust solidified, are known as *Archæan.* Their successors, down to the rocks which contain the coal measures, are known as *Primary,* because they come first in the geological record; the later rocks, down to the cretaceous rocks which form the great chalk deposits of southern England, are known as *Secondary;* while the remaining rocks, which are of comparatively modern origin, are divided into *Tertiary* and *Quaternary.* Each of these periods is subdivided for convenience into a number of shorter periods of rock formation, which are known as systems; and it will be found that the rocks in each of these systems are distinguished by a certain number of common characteristics. The table below, beginning with the most recent, gives a brief summary of the various divisions and systems into which the rocks of our islands are divided:

W. E. GARRETT FISHER

THE ORDER OF THE STRATIFIED ROCKS

Division	System.	Typical Rocks.
Quarternary	Post-glacial or Recent Glacial or Pleistocene	Alluvium and river gravels Boulder clay
Tertiary	Pliocene Miocene Oligocene Eocene	Norwich Crag Lacustrine deposits Isle of Wight fluvio-marine series London clay
Secondary	Cretaceous Jurassic Triassic	Chalk and greensand Portland stone and lias New red sandstone
Primary	Permian Carboniferous Devonian Silurian Cambrian	Magnesian limestone and sandstone Coal measures Old red sandstone Slates and sandstone Welsh slates
Archæan	Pre-Cambrian	Gneisses and schists

Smiths' Tools and their Use. Forging Iron and Steel. Drawing Down, Fullering, Upsetting, Bending, Welding, Punching and Drifting.

THE WORK OF THE SMITH

WE now go into the smithy, and observe the methods practised there. We find conditions of an entirely different character from those which exist in the foundry—conditions which are inseparable from the difference in pouring molten, and in shaping plastic metal. The nearest approach ever made to the molten state of metal in the smithy is when a welding heat is taken on iron, at which the surface becomes partially fused, so that isolated globules drop off as the bar is taken from the fire. If wrought iron were to be fused like cast iron, it would become partially carbonised, and so lose the pasty condition which renders it of so much value. On the other hand, cast iron could not be hammered, but would at a red heat become absolutely fragile and rotten. These differences explain the cardinal differences in the practice of the two departments.

Wrought iron and mild steel when heated to temperatures corresponding with a full red or white heat become pasty and plastic, and in this state will endure any amount of hammering and reduction in size, or of bending and rolling; while at a full or dazzling white heat they can be welded. Their malleability and ductility enable them to endure the most severe treatment without loss of strength, and, in fact, such work done upon them, provided proper precautions are observed, increases their strength, without reduction in ductility and malleability. But before proceeding farther it is necessary to point out the important differences between iron and steel, with the corresponding differences in the methods of working them.

Differences in Working Iron and Steel. Chemically, there is no distinction worth mentioning between wrought iron and the mild or low carbon steel that is used for forgings. But there are great differences in their physical characteristics, and in the methods of working them. Iron has very pronounced fibre, steel has none, except a negligible amount that is developed in rolling. Iron has some four tons per square inch more of strength along the direction of the fibres than across them. Steel is equally strong in any direction. Iron is fibrous because it has been piled, welded, and rolled in layers. Steel is homogeneous because it has been melted and poured previous to being rolled. Because iron is fibrous, it welds better than steel. On the other hand, its bundles of fibres prevent it from being upset or enlarged so readily as steel. Steel is stronger than iron, and more ductile, and, therefore, it can be bent more, and can be elongated, drifted, and reduced in section more before it fractures than iron. The same steel can be both cast and forged; not so wrought iron.

The Smith's Tools. Such being the materials in which the smith works, we find their characteristics reflected in the tools and appliances employed by him. They are hammers, and numerous hammer-like tools, in which moulding or shaping processes are combined. Fullering tools, flatters, swages, punches, drifts, are the predominant forms. The appliances are also swages and swage blocks, bending blocks, dies, and allied forms, in which metal is coerced by impact or pressure into any desired shapes. The leading forms are shown in the group **126–133**.

The actual cutting tools are represented by the *cold* and *hot setts*, or *chisels* [**124** and **125**], variants on these being the *hollow setts*, or *gouges*, having edges curved instead of straight. The group of tools in **126** to **133** all mould, but do not cut. Fig. **126** is a *fuller*, or *fullering tool*, straight crossways, used for rapid reduction of stock; **127** is a *curved* fuller, for working close up to a boss; **128** forms isolated spherical depressions; **129** is an *anvil fuller*, used in opposition to the fullering tool [**126**]. After a surface intended to be flat has been fullered, it is smoothed with a *flatter*, or *sett hammer* [**130** and **131**]. If the object be required of circular form, it is finished—and often fullered down also—between *top* and *bottom swages* [**132** and **133**], the latter being *anvil swages*. To avoid having top and bottom tools separate is the object of the *spring tools* [**134–137**], in which the two are combined, and united by spring handles that permit of opening and closing. Fig. **134** will be recognised as a pair of fullers, **135** as top and bottom swages, **136** as three pairs of different sizes, between which in rapid succession a round bar is reduced, and **137** as a single pair with the hole at right angles to that in **135**. In the *swage block* [**138**], which is in incessant use, the edges are simply an aggregation of bottom swages of varying shapes and sizes, while the holes with which it is pierced form fulcra for use in bending bars. The *anvil* [**139**] is simply an appliance on which work can be fullered, flattened, and bent, the *beak* being much used for turning eyes, while bottom swages, and the cutter, or the anvil fuller [**129**], are inserted in the hole.

Hence no tools used by smiths, except those employed for the actual severance of bars and work, are cutting tools. In this respect the work of the smithy stands apart from other trades. If a bar has to be reduced, it is not done by cutting, but by *fullering*. All finishing processes are effected with tools that are destitute of sharp edges. Fullers, swages, even flatters, have slight convexity on their edges, so that no keen angles are left anywhere on the work, and

there is no severance of fibre, but only a moulding process.

Materials and Tongs. So also the forms in which the materials are rolled are very simple and very few. They comprise round rods and bars of square and rectangular sections, and from these almost all conceivable shapes are produced by processes which are in their essentials few and simple. These forms have their counterparts in the tongs by which they are handled [**140** to **151**]. Figs. **140** and **141** are both *flat-bit tongs*, for flat bars. The first are *close*, the second *open mouth*—meaning, that the former are used for thinner, the latter for thicker bars. Fig. **142** is the *crook-bit tongs*, which hold a long bar parallel with the handles, secured by the crook or lip on one jaw. Fig **143** is the *hoop tongs*, for holding hoops or bars at right angles with the handles. Fig. **144** is a form of *pliers* for picking up light lengths of rod, or holding punches and drifts, and **145** shows the *pincer tongs*. Into the hollow space the heads of bolts, collars, and extensions on work may enter. The jaws are often notched, or veed. Fig. **146** represents the *hammer tongs*, which pick up work having holes, the points entering into the holes; **147** is a form of *pliers*, the jaws being often veed as in **148**, and the space behind serving the same purpose as that in **146**. Fig. **149** is the *hollow-bit tongs*, for gripping circular bars; and **150** and **151** are *flat-bit* tongs of two kinds, with edges turned up to retain bars sideways.

All these tongs are handled like **140** and **141**, though the handles are not completed in the rest of the illustrations. As the grip of the smith would not be strong enough to hold them in close contact around the work, they are tightened by a ring, A [**140**], driven over the handles with a hammer. The ring is termed the *reins*, or the *coupler*.

Forging Operations. The processes of forging may be classified broadly as follow: Drawing down, upsetting, bending, punching, welding, all of which we shall consider in turn.

Drawing Down. As from a piece of bar or rod of uniform dimensions forgings have to be made with cross sections of different sizes, there are two methods of producing such differences. One is by reduction from a larger to a smaller (*drawing down*), the other by enlargement from a smaller portion (*upsetting*). The only alternative to these is welding pieces of different dimensions together, but this method is reserved for some rather unusual cases, to be noticed presently.

Drawing down is the operation which, when conditions are favourable to it, is universally adopted. The principal condition is generally a length not too great to be reduced conveniently. For example, while **152** and **153** are suitable cases for reduction, the relative lengths of the sections have to be considered. Work is on the border line when there is a much greater length, B, to be drawn down from the bar of diameter A [**152**]. If the portion B were, say, several feet in length, the method of drawing down would be very seldom adopted, because of the amount of work it would entail, though the forging would be none the worse, but better for hammering. Fig. **153** is an excellent case for drawing down.

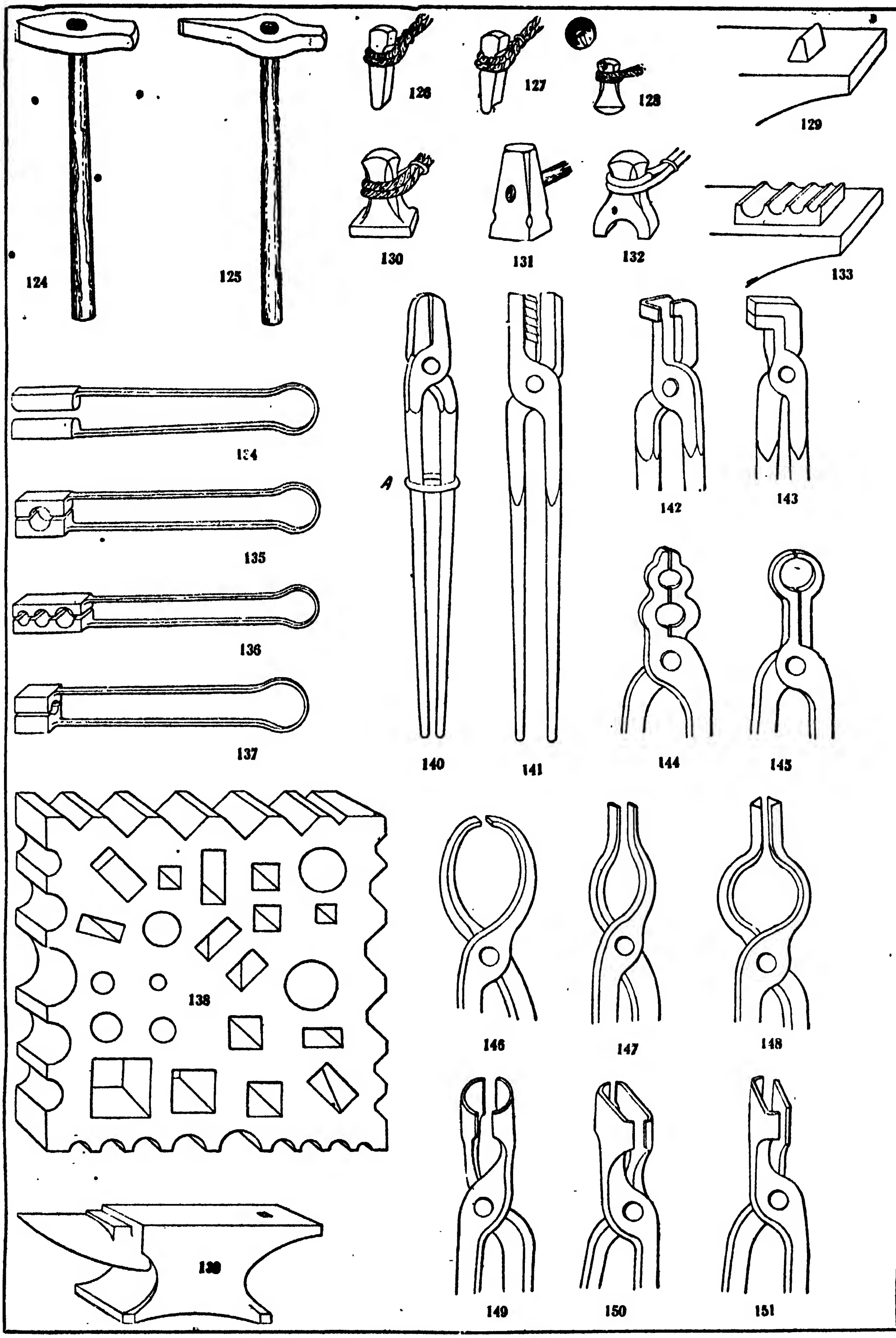
Power Hammer Work. But a most important governing condition which often decides the smith to draw down a greater proportionate length than **152**, is the possession of a power hammer. There is a vast difference in reducing laboriously on the anvil by fullering tools and sledge, and doing the same work under a steam or drop hammer with a falling weight measured in tons. Where such are available, the smiths use up any odd chunks of metal and reduce them how they choose, often drawing down ends from 3-in. or 4-in. pieces of bars, to 1 in. or less at a single heat. The work is easy and simple, being confined to turning the pieces about between the hammer blows. But, obviously, there is a limit to this. Suppose that an enlarged end, 6 in. long has to terminate a rod 20 ft. long, it would be practically impossible to reduce such a length, or anything approaching it, so that drawing down is then out of the question.

Another governing condition is the shape of the enlarged end. In **152** and **153** there is no difference in the shapes of the larger and smaller parts. There are differences in **154**, **155**, and **156**; and **154** is on the border line. Its flat foot A, and bosses B and C, are not so very greatly different in section but that they might be formed by upsetting, nor are the lengths of the stems so great but that they may easily be formed by drawing down from bar of the size of B, C, with a little upsetting for A. But when there is much difference, as, say, in a tie-rod with eyes [**155**], or a valve bridle [**156**], the making of the eyes has to be considered as of more importance than the plain rod. As a general rule, with very few exceptions, such eyes are made distinct and separate from their rods, and welded on to them. But this also depends on proportions, materials used, and on facilities afforded by power appliances; **156** would, if made in steel in stamps, be made by drawing down.

If eyes are of small diameter, and the rod short, then they are made from one piece, the rod being drawn down. If the eye is large, and the rod short, the job is on the border line where different methods might be selected. If the rod be very long, say several feet, then a separate plain rod is taken for that, and welded to the eye previously forged separately.

Another condition is that of work having arms standing out at right, or nearly right, angles. To draw down such pieces, the bar must be slit, forked, and opened out. This is often done, but, generally, welding is preferable. The foregoing are typical of many groups of work that occur in the smithy.

Iron and Steel. Whether a forging be made in iron or in steel must often determine the preference for one method over another. It applies particularly to welding. Welds in iron are, with the exercise of reasonable care, as safe as solid metal. Those in steel are not so reliable, and the risks increase rapidly with higher



SMITHS' TOOLS

124. Cold sett **125.** Hot sett **126.** Fuller **127.** Curved fuller **128.** Boss fuller **129.** Anvil fuller **130.** Flatter **131.** Sett hammer **132.** Top swage **133.** Anvil swage **134.** Spring fullers **135-137.** Spring swages **138.** Swage block **139.** Anvil **140.** Close-mouth flat-bit tongs **141.** Open-mouth flat-bit tongs **142.** Crook-bit tongs **143.** Hoop tongs **144.** Pliers **145.** Pincer tongs **146.** Hammer tongs **147, 148.** Pliers **149.** Hollow-bit tongs **150, 151.** Flat-bit tongs

contents of carbon. Many engineers will not have steel welds at all, or if they do, they only allow them a moderate percentage of the strength of the solid bar. The fibrous character of iron is eminently favourable to welding, but from other points of view it has its drawbacks, some of which we must now notice.

If a bar of steel be used for a forging, the smith need take no account of fibre. That is, he can cut it, punch it, and work it to any required shape, knowing well that its strength will be alike in every direction. But in working iron he has to take account of the direction of the fibre of the iron almost as much as the carpenter has to consider the grain of the timber he uses. Failing to do this, there are many forgings, the shape of which is such that they would open out or fracture, through the short fibre, when subjected to working stresses. A hundred examples might be selected, but a common loop, or eye [**155** and **156**], illustrates the idea excellently.

Such eyes, if made in steel, are produced by punching a hole and slightly enlarging it by drifting. But if punched in iron the fibre would be short at A, and the chances are that the eye would open out or fracture at A, and the risk would be the greater because the punching and drifting would have tended to separate the fibres there. The poorer the quality of the iron, too, the greater would be the risk. Such an eye, if made in iron, would have to be produced by bending rod round, and welding. Then the fibre would run round the eye, and would be unbroken and of equal strength everywhere.

Fullering. Drawing down is done by direct hammer blows, which method is, however, suitable only when the reduction is slight in amount. More commonly it is effected by the process termed *fullering*, which effects more rapid reduction by a series of hammer blows dealt by the fullers or tools with convex edges, as in **157**. The result is that the surfaces of the bar are indented with a series of corrugations, being at the same time reduced rapidly in thickness. When the greater part of the reduction has been effected in this way, the ridges are obliterated, and the surface smoothed level, and finished with flatters [**160**].

The foregoing is merely a bald statement of the work of fullering, which varies in different kinds of objects. When a piece of bar of rectangular section is being thus reduced, the smith turns it about from faces to edges alternately, so effecting reductions at right angles, instead of working on faces first and edges afterwards.

Tools for Fullering. When work is being fullered on the anvil, the bottom fuller may be just like the top one [**157**], in which case the reduction is effected on opposite faces of the bar. The bottom one is then generally an *anvil fuller* [**129**], so called because it is fitted in the hole in the anvil similarly to the anvil stake. Often, however, the work is laid directly on the anvil, and fullered on the top face only [**158**]. This would always be done when one face of the forging was flat—that is, without a boss or other projection standing up therefrom.

In drawing down an object of circular section, the fullers are seldom used, but the hammers only, from start to finish, because less labour is required to reduce such a section than one having flats. Where a power hammer is available, reduction is easily effected between the flat faces of the tup and anvil, turning the work about between each two or three blows [**159**] to present fresh edges, and so effect the reduction uniformly. Very often these reductions are effected in dies, to which we shall come presently.

Fig. **160** illustrates the finishing of a surface previously fullered, with a flatter, or sett hammer, on the anvil; **161** shows a circular rod being finished between top and bottom swages, also on the anvil, for which spring swages [**134** to **137**] might alternatively be employed, or the edge of the swage block [**138**] and a top swage. In **162** another method of fullering under the steam hammer is shown, a round rod being used to effect the fullering, struck by the tup.

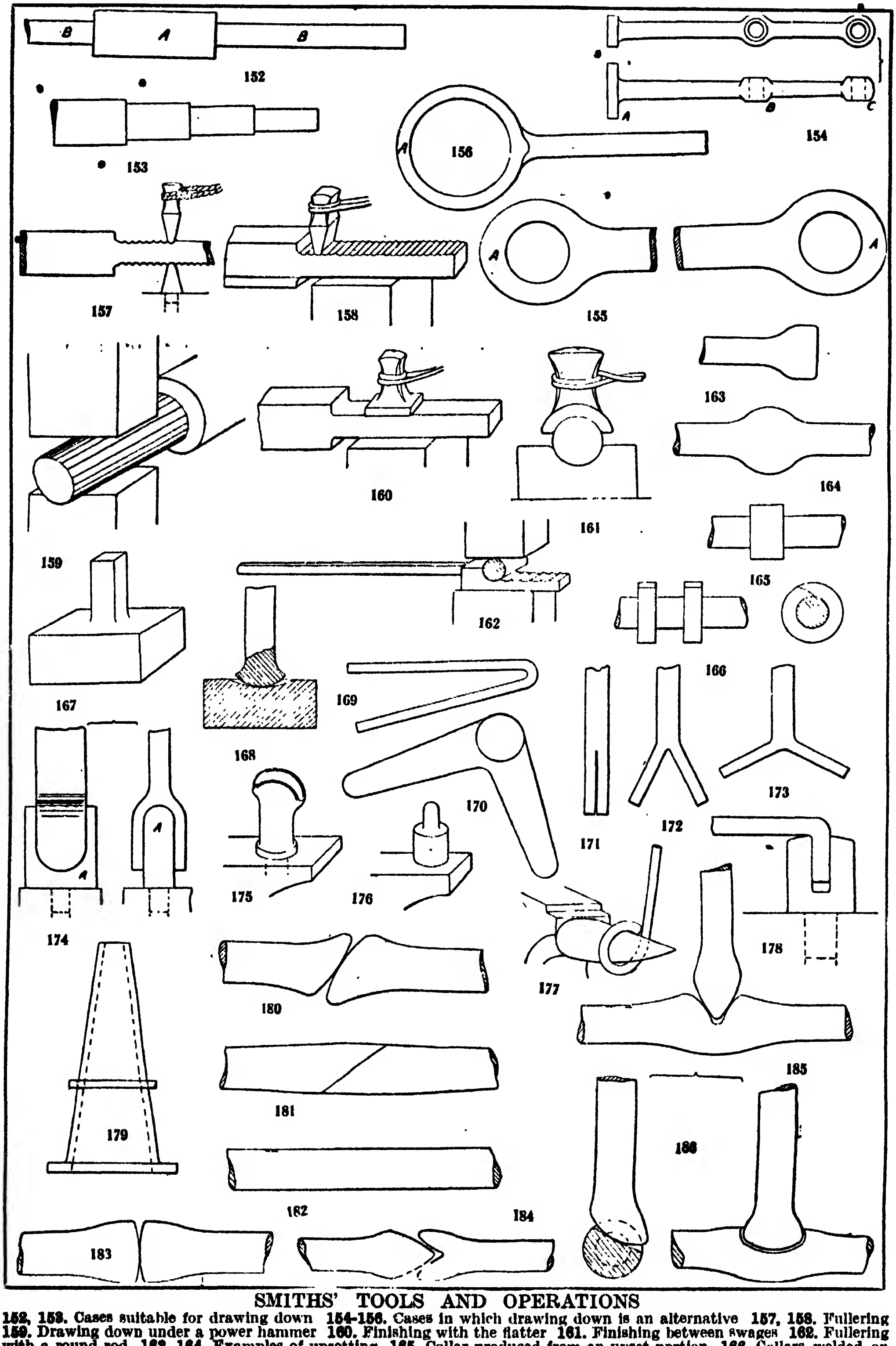
Upsetting. This is the general alternative to drawing down, and the conditions suitable for its employment are the reverse of those which we have stated as being favourable to drawing down. If a small enlargement be required at the end or central portions of a bar, and not of excessive length, as at BC [**154**], that is a case for upsetting. It is not a desirable process in wrought iron, because it tends to open the fibres.

The term expresses literally the nature of the operation. A *short heat*, or localised heat, is taken only, over the part to be enlarged, and the metal is thrust out laterally [**163** and **164**]—that is, upset by blows delivered on the end of the bar. These are given by *up-ending* the bar on the anvil, or on the floor-plate, and bumping it up and down a number of times; or, if too massive to be handled, it is laid horizontally on the anvil, and blows are delivered on the end by a swinging monkey. This is suspended from a beam by a rope, and drawn back by helpers at another rope, and let go to make impact against the end of the bar.

Obviously, the amount of lateral extension possible is very limited. An extension of 1 in. bar to 2 in. over a length of 2 in. or 3 in. would be a very considerable quantity of upsetting to accomplish. So that this device is seldom adopted, excepting on short lengths, and then generally when the original size of bar is of good length—say 2 ft. or upwards. If shorter than this, drawing down is preferable.

If much enlargement be necessary, then the fibres should be closed and consolidated afterwards by hammering them at a welding heat. In iron it is generally preferable to resort to welding.

An upset portion is always of rather irregular shape, and correction is necessary, if definite shapes are required. Thus the collar [**165**] can be produced from an upset mass by subsequent swaging. But if two collars were required [**166**] the work would be simplified by welding the two on as rings, as shown, rather than by upsetting



SMITHS' TOOLS AND OPERATIONS

152, 153. Cases suitable for drawing down **154-156.** Cases in which drawing down is an alternative **157, 158.** Fullering **159.** Drawing down under a power hammer **160.** Finishing with the flatter **161.** Finishing between swages **162.** Fullering with a round rod **163, 164.** Examples of upsetting **165.** Collar produced from an upset portion **166.** Collars welded on bar **167, 168.** Article formed by welding preferably to upsetting **169.** Bar easily bent **170.** Lever bent with difficulty **171-174.** Stages in the formation of a forked end **175-178.** Aids to bending **179.** Conical stand for bending rings round **180-183.** The scarf weld **183.** The butt weld **184, 185.** The vee weld **186.** Scarf weld at right angles

and swaging. The article in 167 looks like a job for upsetting, but it is not so. The discrepancy in stem and body is too great. The proper way to make this also is by welding the stem to the body, as in 168.

Bending. This operation is constantly being done, generally alternating with other operations. Some jobs are practically "all bending." It is accomplished in many ways, and, with few exceptions, at a red heat. Some objects cannot be produced by bending, and then welding or some other device, such as stamping, is the alternative.

Bending can be performed properly only when the radius or angle is such that the inner layers of metal are not crumpled, nor the outer ones attenuated. What happens when a bar is bent is that the layers of the inner curve are squeezed into and occupy a shorter distance, and the outer layers are extended and occupy a longer distance. Between the zones of compressed and extended fibres there is a layer—the neutral axis—where the fibres undergo neither change. This, it is well to observe, is the zone on which the actual dimensions for curved work have to be measured.

Limitations of Bending. Now, it is easy to see that iron and steel are only capable of moderate compression and extension; steel more than iron, but limits are set to both. The greater the distance between the neutral axis and the extreme edges, the harder will be the work of bending, and the greater the amount of crumpling and stretching. Thus the bar [169] would be easily bent to an acute angle as shown, but the broad, flat web of the bell crank lever [170] would be very difficult to bend, and should preferably be formed by welding two webs at right angles.

Bending is often preceded by division of a bar. Thus, 171 to 173 represent three successive preliminary stages in the making of a forked end. In 171 the bar to be used is divided from opposite faces with the hot sett [125]; in 172 it has been partly opened out; in 173 spread out more, but without nicking of the fibre at the root. Then in 174 it is finished by hammering round the form A held in the anvil (or other equivalent fastening). Other examples of aids to bending on the anvil are 175, a block for short radii; 176, a block for turning complete rings, done alternatively on the anvil beak [177]; and a block [178] for bending bars to angles; 179 is the conical stand for bending rings.

The methods of bending are therefore varied. Bars are bent by pulling them round mandrels with the tongs or the hands, or by hammering, or pulling and hammering alternately. Mandrels are any loose rods selected of the size required for a given radius, and are often held in the hand. Often they are specially made to fit in the hole of the anvil. The holes in the swage block serve as leverages for bending bars inserted therein. The anvil beak is utilised as a mandrel. Many bending blocks are made for special jobs, used apart from the power hammers, or with them. The shop conical mandrel stand is used for bending large radii and rings.

Welding. The ability to unite two pieces of wrought iron or steel at a white heat is work peculiar to the smithy. This property is invaluable both from constructive and economical points of view. It would be extremely difficult to manufacture some classes of objects without this aid; it would increase the cost greatly in a larger number of cases.

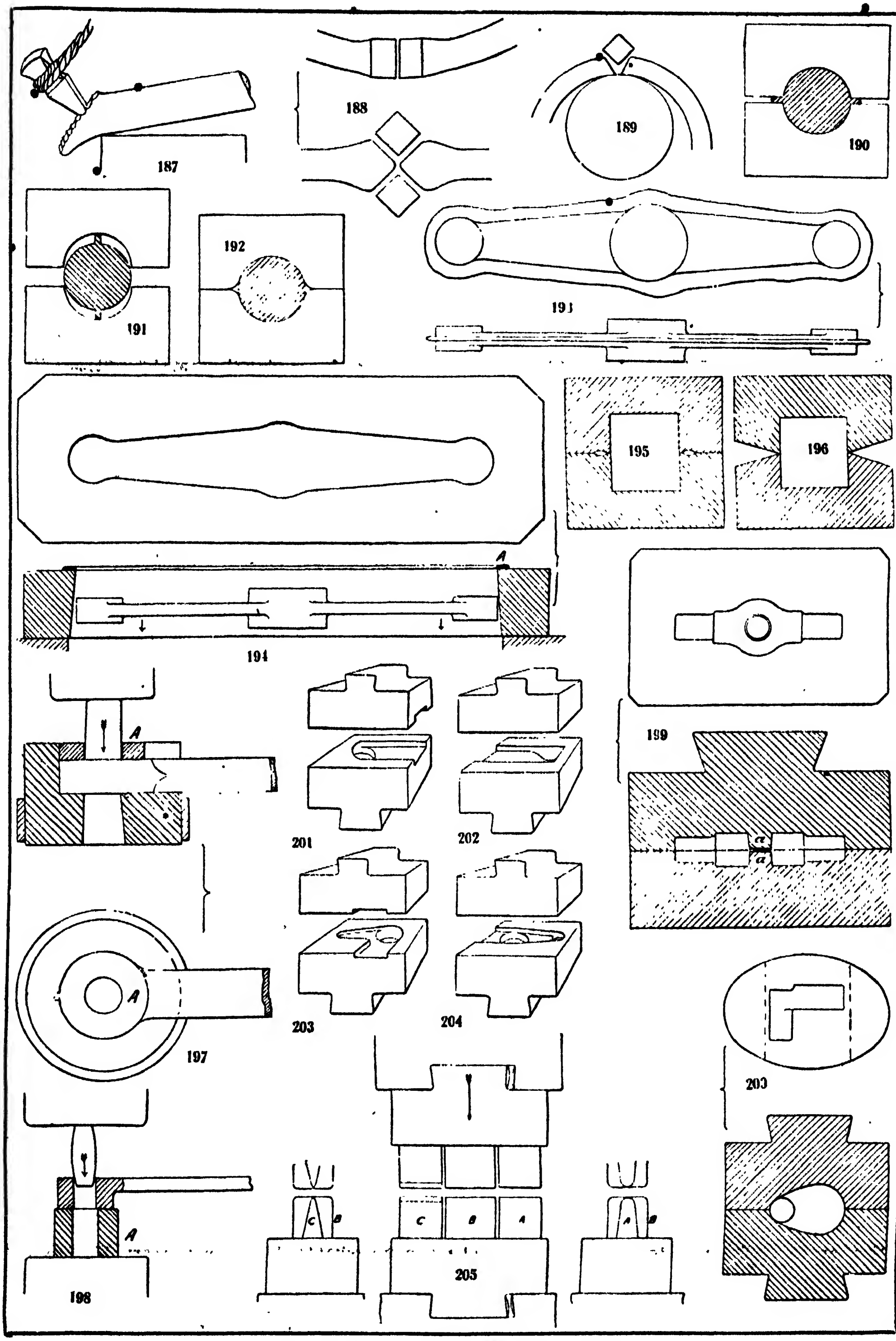
The difference between welding and soldering, or brazing, the operations which it most resembles, are that these are effected by a cementing material applied between cold surfaces, while welding is an autogenous process in which surfaces are united by impact or pressure while in a semi-fused condition. A good weld is as strong as the unwelded portions.

The forms of welds are varied with the shapes and relations of the parts to be united. They include the *scarfed* form, the best and most common; the *butt*, least satisfactory unless the surfaces united are of good area; the *vee*, and its allied form, the *glut*. In any weld joint the expulsion of the scale is an essential object, and so we find that certain precautions are taken in making the joints, the reasons for which would not be understood by a beginner.

The Scarf Joint. Fig. 180 shows two ends prepared by scarfing for this form of weld. There are three points to notice—the length of the scarfing, the upsetting, and the convexity of the opposed faces. The length is properly about that shown. A shorter scarf gives less holding area, and in a much longer one there is risk of some of the scale remaining entangled in the joint. The upsetting, or enlargement, is imparted in order to give excess of metal over that of the body of the bar. If this were not done the welded part would be smaller when finished than the rest of the bar, and therefore weakened and unsightly. The convexity is imparted to cause any scale present to be squeezed out by the act of welding. Fig. 181 shows the appearance of the joint after it has been closed, and 182 after it has been swaged and finished neatly.

The Butt Weld. This [183] is, as its name implies, a weld in which two surfaces, either quite flat or slightly convex, are brought into opposition and welded. The process when applied to flat surfaces is often termed *dabbing on.* Bosses are welded thus to plated portions to avoid the labour of drawing down the plated part from the boss. Rods and bars are welded at right and other angles by this form of joint, alternatively to the vee and scarf. The same precautions are taken as in making the ordinary scarfed joint.

The Vee Weld. A vee weld [184] may be regarded as a double scarfed one. Its value lies chiefly in making joints at right or other angles rather than in straight lines. It is considered more reliable than a plain scarf, but is not so quickly made, and is not employed to so great an extent. The upsetting and the convexity of the meeting faces are embodied as in the scarfed form. Fig. 184 joins two bars in line, 185 two at right angles; 186 is a common alternative showing the preparation for one form of scarf weld at right angles, where both the



A VARIETY OF SMITHS' DIES

187. Upsetting an end by fullering **188, 189.** Glut welds **190-192.** Formation and obliteration of fin **193.** Forging with fin **194.** Stripping die for same **195, 196.** Provisions in dies for receiving fin **197.** Punching in dies **198.** Drifting **199.** Punches in dies **200.** Dies that fit by dovetails **201-204.** Dies for bossed ends **205.** The Brett system of roughing out

upsetting and convexity are embodied; 187 shows the usual way in which an end is upset for a scarfed joint. The bar is held at an angle across the edge of the anvil and spread out by blows on the fullering tool. Afterwards it is smoothed by hammer blows.

The Glut Weld. A glut weld [188 and 189] is a variety of the vee. It is, however, employed more by boilermakers than by smiths. The latter use it chiefly in welding up rings of rectangular cross section, but it is alternative to a scarfed joint.

Precautions. The precautions to be taken in welding are few in number but very essential, as follow.

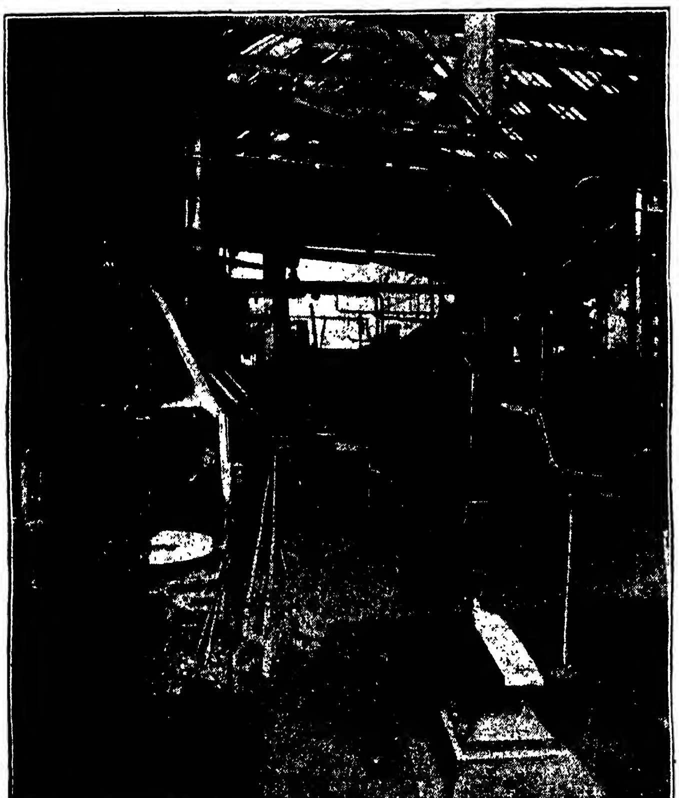
The heat for welding must be graded according to the material. Iron may be, and is generally, raised to a heat so white that globules of metal drop from it as it is taken from the fire to the anvil. But such a temperature would ruin steel by producing burning or oxidation. A full white heat is the limit for steel. There must be no scale (oxide) or dirt present on the faces to be united. Therefore, the heat must be taken in a hollow fire away from contact with coal. Sand or other flux is dusted on the metal in the fire before it is removed to the anvil. A file is often brought into requisition to remove scale. Sand is dusted on the work at the anvil, and over the anvil on which it is laid to be welded. All these precautions are more essential with steel than iron.

The closing of the weld must be done *quickly*, and with *light* rather than heavy blows. Generally the hand hammer only is used, the sledge following after, or being reserved only for massive work. If the weld be not closed in about the first eight or ten seconds, no amount of subsequent hammering will make it good, because the necessary heat will be absent. A weld can be made only when the surfaces in contact are nearly at fusing point. Afterwards the jointed portion is finished neatly at leisure. [See also Welding, in METALS, page 1848.]

Punching. A good deal of forging involves the making of holes by driving a punch through the metal and enlarging the same laterally—*drifting*. The operations are, therefore, distinct, though often employed on one piece. Thus a large hole cannot be formed by punching alone apart from power aids. The practice at the forge, therefore, is to punch a small hole, say, of $\frac{3}{4}$ in. or 1 in. diameter, and enlarge it by driving tapered drifts through it.

Obviously, a process of drifting has to be employed carefully, bearing in mind the remarks already made respecting the opening out of the fibres by upsetting, and the short fibre in some shapes. Thus the eye in a previous illustration [156] would not be a suitable article for formation by punching and drifting; but it would be much worse if made in iron than in steel, because steel has no difference in fibre. Another reason is that steel has from three to four times the ductility of iron, and will therefore endure as much more stretching. These are points that have a very important bearing on the selection of iron and steel for a given job. The use of mild steel, highly ductile, has changed much of the work of the smith, lessening welding and multiplying the forms that can be produced by the aids of punching and drifting. Fig. 156 would very well be made in steel if the hole were punched out at once, nearly or quite, to full size. But it would be bad in iron because of the short fibre at A, and worse still if drifted. The same remarks apply in a slightly less degree to 155. But 154 would be an excellent case for punching and drifting.

Proper Employment of Punching. The proper place of punching and drifting operations, therefore, is in the smaller eyes and bossed ends, and if in steel, the larger ones also. The effects of excessive extension of fibre in steel can



206. VIEW OF A SMITHY. By courtesy of Messrs. Mather & Platt, Ltd., Salford

be largely counteracted by compression in the contrary direction, work which is best done in dies coercing the outside.

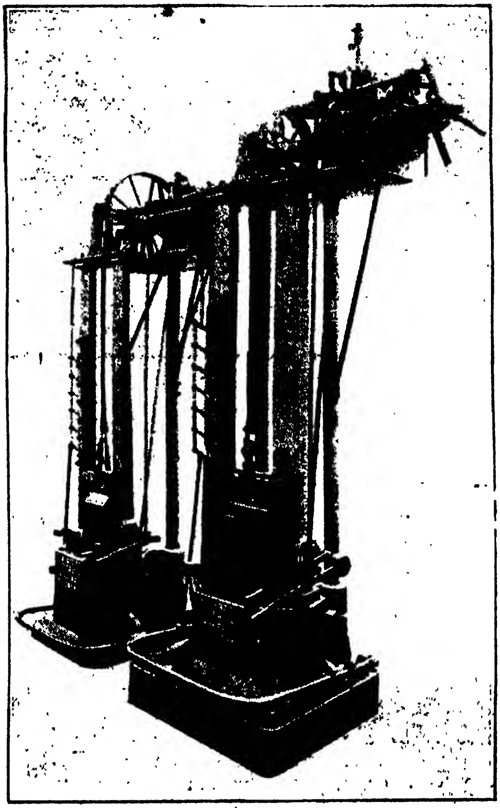
The methods of punching and drifting at the anvil are as follow.

The piece of work to be punched, being brought to a white or full red heat, is laid upon a *bolster*—a ring with a hole in it for the punching or burr to fall into. The punch, generally handled by withy rods, or iron rods, is driven by a sledge. If the work be shallow the punch will go right through; if not, the work must be turned over and the punch driven from both sides, meeting in the middle. If the mass of the boss be small, it will be enlarged by the act of punching, and will have to be corrected subsequently. If large, the metal will not yield sensibly in the lateral direction.

Drifting. *Drifting* means the insertion of tapered drifts made in sizes required. These are driven through with a hammer, successive ones being inserted until the required dimensions are obtained. Reheating may have to be done, because drifting stresses the material severely, and must, therefore, not be done except at a good red heat. Generally the outside is corrected with hollow swages while the drift remains in its hole, and this consolidates as well as imparts a neat finish to the bossed portion.

Die Forging or Stamping. Hitherto we have considered the work done at the anvil by methods that vary little in the hands of the country smith or the engine smith in the factory. But this is becoming a rapidly lessening volume, invaded by the work of the dies and power hammers. The subject is a wide one, and the practice is greatly subdivided now, being alike adaptable to the preparation of a few similar forgings or of thousands. Work may also be done partly at the anvil and partly in dies, or wholly in dies. A big piece may require two or more heats for its completion, or three or four small pieces may be forged at one heat. A good many different types of hammers and of forging presses are used in this work, actuated by steam, belt, board, compressed air, and water. Some shops will have but one hammer or press, others will number a hundred or more. The work has become of a cut and dried character, and grows more highly specialised constantly.

Removal of Fin. The principles of die forging are simple enough; the details tend to increase in complication. One difficulty lies in the formation of *fin*. That is, if a lump of metal be squeezed between dies, the surplus material becomes squeezed out between the joints of the dies, and forms fin. This has to be got rid of. There are two ways of doing so, depending on the shape of the forging. One is by obliteration, the other by cutting off in stripping dies. The first is suitable only for pieces that can be turned about in the dies, and these are only those of circular and square sections. Thus, in **190**, a bar is in course of reduction between dies, but the dies cannot close and finish the bar to the circular form because of the extension of the fin into the joints. But if the bar be turned



207 BRETT DROP HAMMER WITH PATENT LIFTERS
Brett's Patent Lifter Co., Ltd., Coventry

round as in **191**, the fin will be obliterated by being squeezed into the body of metal. More fin, but a less amount will form, of course, in the joints, but by turning the bar round constantly during the time it is being reduced the fin will be obliterated as rapidly as it is formed, and a truly circular shape will result. This fact also explains why in simple circular dies square edges are not necessary or even desirable, but a slight convexity is usually imparted as being favourable to the expulsion of fin, and to the turning round of the bar [**192**]. There is enough of the circle left to ensure the production of a circular shape on the bar which is being rotated in the dies. Bolts are forged in quantity in dies of this shape in the Ryder forging machine.

Other Methods. But take any object that cannot be rotated, and the inevitable formation of fin renders some other device for getting rid of it necessary. It may be removed either by a hand hammer, a few blows from which will detach it all round the hot forging, or, in a better system, by using stripping dies; thus, **193** shows a double-ended lever with the fin as formed around it during the act of forging. The stripping die [**194**] has the same outlines as the recess in the forging die, and its lever. But it is pierced right through to those outlines, so that when the forging is hammered down into it, the forging drops

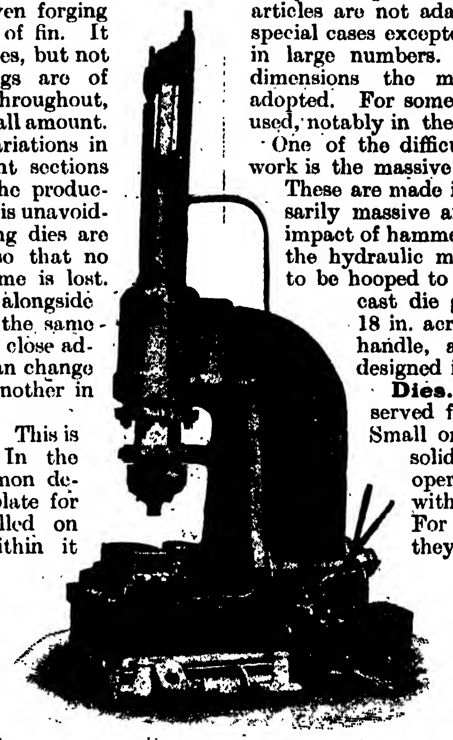
through, leaving the fin, A, upon the face. In some forgings this stripping has to be repeated more than once. In another form of die the fin is squeezed out sideways, and left on the forging, to be cut off at any subsequent time. The die faces are then either recessed [195], or sloped [196], to receive the fin, the latter method being preferable.

The question might be asked whether it is not possible to estimate the amount of metal required to produce a given forging without having an excess of fin. It is in forgings of some shapes, but not in others. When forgings are of tolerably uniform section throughout, fin may be reduced to a small amount. But when there are big variations in the dimensions of adjacent sections the formation of fin in the production of the smaller sections is unavoidable. And when stripping dies are used they are arranged so that no appreciable amount of time is lost. They are either mounted alongside the formative dies under the same hammer, or on a hammer close adjacent, so that the man can change the forging from one to another in a moment.

Punching in Dies. This is done in several ways. In the engineers' smithy a common device is to use a guide plate for the punch, either dowelled on the die, or dropped within it over the forging as in A [197]. The punch is then bound to produce a central hole. The next [198] shows a drift being driven through a hole without effecting much enlargement. A is the bolster. Fig. 199 shows punches, *a a*, embodied in the dies themselves, which is generally done when the work is produced in large quantities. Fig. 200 shows a pair of dies that fit with dovetails into both anvil and tup.

Figs. 201 to 204 are some examples of engineers' dies. The point to note in these is that the complete forging is not included in the dies, but only bossed ends. A good deal of such work is done in engineers' smithies.

Stamping. In the regular stamping shops the anvil occupies no place in the scheme of operations, but the hammers and dies are ubiquitous. Fig. 205 illustrates an arrangement where small work is being done in quantity, the "Brett" system. This serves two drop hammers, to right and left, under which two sets of work are being finished. There is also a trimming press for removing fin locally. The arrangement shown enables two forgers to rough out at the central hammer, leaving only the slight amount of finish to be done in the dies at the other hammers. In 205, A is a nicking or fullering die, B shows the broad forming dies, and C the cutting-off dies. This enables a number of forgings to be made from a long bar.



208. HYDRAULIC FORGING PRESS MAKING STEEL BUFFERS AT SWINDON LOCOMOTIVE WORKS
Fielding & Platt, Ltd., Gloucester

There is, however, an important difference besides that of the numbers required off given forgings. The articles made in stamping shops are mostly of small dimensions and, therefore, they are eminently suitable for wholesale treatment. But engineers' forgings comprise many examples of massive work. Now, such articles are not adaptable to die forging, some special cases excepted, and they are not wanted in large numbers. For forgings of medium dimensions the method just mentioned is adopted. For some also the hydraulic press is used, notably in the railway and waggon shops.

One of the difficulties in dealing with heavy work is the massive character of the dies used. These are made in cast iron or steel, necessarily massive and strong to withstand the impact of hammer blows, or the pressure of the hydraulic machines. Often they have to be hooped to prevent fracture. When a cast die gets much beyond 15 in. or 18 in. across, it becomes awkward to handle, and liable to break unless designed in a very careful fashion.

Dies. Cast dies are mostly reserved for relatively massive work. Small ones are generally cut out of solid steel. This is often a tedious operation, done in machines, or with chisel, hammer, and file. For forgings of intricate shapes they are costly, but if the expense be spread over a large number of forgings, a die costing several pounds may cost only a fraction of a penny per forging made.

The dies of the engine smithy are frequently independent of the hammer on which they are used. The bottom die is simply laid on the anvil, and the top die laid over it, with the forging between, and is struck by the descent of the tup. But in the stamping shops the bottom die is attached to the anvil with set screws or with a dovetail, and the top one attached to the tup with a dovetail. The smith then only has to manipulate the forging with his hands. Generally, except in heavy machines, he regulates the vertical movements of the tup with one of his feet, operating a lever, so leaving his hands unfettered for the forging.

A typical smithy is shown in 206. On the left are the forges, served by swinging jib cranes, on the right the anvils and steam hammers.

Fig. 207 shows a pair of drop hammers for die forging, worked by lifters in a cylinder operated by steam or compressed air, moving a wing piston. The tup is hoisted to the desired height and then allowed to drop. Fig. 208 is a hydraulic press, being more powerful than the drop hammers.

JOSEPH G. HORNER

Spanish: Recapitulatory Exercises. German: Comparison of Adjectives. Irregular Verbs. French: The Verbs.

SPANISH

Continued from page 3022

By José Plá Cárceles, B.A.

Before beginning the study of the Spanish irregular verbs, and in order the more thoroughly to master the application of the rules given in the previous lessons, the student should translate the two following Recapitulatory Exercises, in which most of those rules are to be applied.

Exercise XLII

to word	*redactar*	to declare	*declararse*
to come in	*entrar*	to help	*ayudar*
to happen	*suceder*	to hear	*oir*
to find out	*averiguar*	to find	*encontrar*
to resign	*dimitir*	to return	*regresar*
to approve	*aprobar*	to pass	*pasar*
to trouble	*molestar*	to cause	*causar*
to throw	*echar*	to bear	*soportar*
to fight	*pelear*	to incline	*inclinarse*
to overcome	*vencer*	the water	*el agua*
to suffer	*sufrir*	a leaf	*una hoja*
to have just	*acabar de*	the lift	*el ascensor*
the sea	*el mar*	the noise	*el ruido*
the cup	*la taza*	dismay	*espanto*
the staircase	*la escalera*	a concert	*un concierto*
the rustling	*el susurro*	the strike	*la huelga*
horror	*horror*	weary	*fatigado*
a place	*un sitio*	hostilities	*hostilidades*
Castilian	*castellano*	a guest	*un invitado*
a relation	*un pariente*	the choice	*la elección*
the solitude	*la soledad*	the passion	*la pasión*
the avarice	*la avaricia*	destitute	*desprovisto*
how	*cuán*	campaign	*campaña*
severities	*rigores*	the hotel	*la fonda*
the capital	*la corte*	the army	*el ejército*

the first time	*la primera vez*
notwithstanding	*sin embargo*
not anywhere	*en ninguna parte*
His Majesty	*Su Majestad*
the Ambassador	*el Embajador*
the appointment	*el nombramiento*
an explosion	*una explosión*
plenty of time	*tiempo de sobra*
the darkness	*la obscuridad*
to approach	*acercarse*
to have lunch	*almorzar*
to ride (a horse)	*montar á caballo*
to shoot (game)	*cazar*
to confer benefits	*hacer bien*
the damage	*el desperfecto*
fond of	*aficionado á*
patiently	*pacientemente*
exactly	*exactamente*
the privation	*la privación*
through train	*tren directo*
the visiting-card	*la tarjeta*
base-minded people	*villanos*
Christmas Eve	*el día de Noche Buena*
the advertisement	*el anuncio*
Chamber of Deputies	*Cámara de Diputados*
a treaty of commerce	*un tratado de comercio*
The Minister for Foreign Affairs	*El Ministro de Estado*

1. Los invitados eran, en su mayor parte, parientes y amigos suyos. 2. Acababan de almorzar cuando nosotros entramos. 3. Yo le ayudé á redactar la solicitud. 4. No deje Vd. de ir el día de Noche Buena. 5. Al oir (*on hearing*) la explosión nos acercamos á la fábrica para ver que había sucedido. Los desperfectos fueron importantísimos, calculándose las pérdidas en varios miles de libras. 6. ¿ Averiguaron Vds. el nombre del viajero que comió con nosotros en la estación de Valladolid ? 7. Me dió su tarjeta pero debo haberla perdido pues no he podido encontrarla en ninguna parte. 8. Aquella fué la primera y última vez que lo ví. Algunos meses despues me escribió mi hermano para decirme que lo había visto en un hotel de Nápoles. 9. Era alemán pero hablaba el castellano tan bien como un español. 10. ¿ Le gusta á Vd. vivir en el campo ? 11. Sí, soy muy aficionado á cazar y montar á caballo. 12. Se cree que el Gobierno dimitirá tan pronto como su Majestad el Rey regrese á la Corte. 13. Según el Ministro de Estado, es probable que mañana se firme el nombramiento del nuevo Embajador de España en (*to*) Francia. 14. La Cámara de Diputados de Colombia acaba de aprobar un tratado de comercio entre aquella nación y los Estados Unidos. 15. ¿ Ha preguntado alguien por mí ? 16. No; pero creo que hay dos cartas para Vd. 17. Haga Vd. el favor de dármelas. 18. ¿ Cree Vd. que esta noche habrá en el concierto tanta gente como anoche ? 19. Es probable que haya más, pues según los anuncios, cantará un nuevo tenor. 20. Se teme que se declare la huelga general en todas las provincias. 21. ¿ Es éste el tren directo para Madrid ? 22. No; el tren directo sale del andén número cinco. 23. ¿ A que hora llegaremos á Burgos ? 24. A media noche aproximadamente. 25. Permítame Vd. que pase. 26. Con mucho gusto. 27. ¿ Sabe Vd. cuanto tiempo para aquí el tren ? 28. No lo sé exactamente, pero creo que hay tiempo de sobra para tomar una taza de café. 29. Perdone Vd. que le molesto tanto : ¿ Conoce Vd. alguna buena fonda en Toledo que no sea demasiado cara ? 30. Cerca de la estación hay una bastante buena donde se habla francés é inglés. Las habitaciones del último piso no son muy caras. 31. ¿ Hay ascensor ? 32. No; pero la escalera es muy cómoda. 33. Siempre he oido decir que (el) hacer bien á villanos es echar agua en el mar. 34. De todas las pasiones la avaricia es la más difícil de vencer. 35. Los españoles—según Solís—siempre que tienen

elección, se inclinan á lo más difícil. 36. La soledad del sitio, la obscuridad de la noche, el ruido del agua y el susurro de las hojas causaban horror y espanto al viajero fatigado. 37. El ejército de Washington, cuando las hostilidades comenzaron en América, estaba desprovisto de todo lo necesario para soportar los rigores de una campaña de invierno y, sin embargo, ¡cuan noblemente pelearon y cuán pacientemente sufrieron los soldados todas (*every*) las privaciones!

Exercise XLIII

to attempt	*intentar*	to become	*convertirse*
to command	*mandar*	to prefer	*preferir*
to go round	*dar la vuelta*	to fall	*caer*
to sack	*saquear*	to capture	*capturar*
to leave	*salir*	to render	*prestar*
to lead	*orientar*	a comedy	*una comedia*
a task	*una tarea*	the critic	*el crítico*
the art	*el arte*	a caravel	*una carabela*
the world	*el mundo*	a victor	*un vencedor*
a pension	*una pensión*	a habit	*un hábito*
the object	*el objeto*	the appeal	*la apelación*
a ditch	*una zanja*	blind	*ciego*
serious	*serio*	the aim	*el objetivo*
beautiful	*bello*	the loyalty	*la lealtad*
a ducat	*una ducado*	recovered	*restablecido*
cents	*céntimos*	due	*debido*
whatever	*lo que*	the empire	*el imperio*
a colonel	*un coronel*	the admiral	*el almirante*
the clouds	*las nubes*	the dew	*el rocío*

to commemorate	*conmemorar*
to demoralise	*desmoralizar*
to remember	*acordarse*
the retrogression	*el retroceso*
the degradation	*la degradación*
the vanquished	*los vencidos*
the impatience	*la impaciencia*
all others	*todos los demás*
the animalism	*la animalidad*
the memory	*la memoria*
unfortunate	*desgraciado*
the regiment	*el regimiento*
the commander	*el comandante*
the brute force	*la fuerza bruta*
a masterpiece	*una obra de arte*
the blue sky	*el cielo azul*
the green grass	*la hierba verde*
to conquer	*conquistar*
to be bored	*aburrirse*
to settle	*cancelar*
to undertake	*emprender*
the coat-of-arms	*el escudo de armas*
to agree with	*estar de acuerdo*
it is the same for me	*me es igual*
seriously ill	*gravemente enfermo*
a matter of taste	*una cuestión de gusto*
to spend the time	*pasar el tiempo*
the return journey	*el viaje de vuelta*
an immense booty	*un inmenso botín*

1. We have come by (the) train. 2. Where did you spend the night? 3. We have been travelling since yesterday afternoon. 4. How much do I owe you? 5. You owe me seven pesetas and 25 cents. 6. How many pence are there in a peseta? 7. A peseta has 100 cents, which are about tenpence. 8. Did my friends pay you? 9. They settled their account before you arrived. 10. Have you (got) change for (*de*) a five-pound note? 11. I think so. Do you want silver or gold? 12. It is the same for me. Whatever may be better for you. 13. Pizarro conquered the Empire of the Incas with less than 200 men. 14. Have you ever been in Peru? 15. Last year I spent two months at Lima. It was an extremely interesting journey. My sisters are there now. 16. How are they? 17. According to the last letter we have received, one of them—the youngest—is seriously ill. 18. I hope she is (*que ya estará*) quite recovered by now. 19. Why did you not applaud your friend's comedy? 20. I did not like it. I was bored. 21. To write a good comedy is a somewhat difficult task. 22. I agree with you He ought not to have attempted it. 23. However, several critics assert that it is a masterpiece. 24. Probably (*tal vez*) they are right. After all, it is a matter of taste. 25. Where impatience has become a habit, failure is certain. 26. Do you wish to undertake the return journey by sea? 27. I should prefer it if it were possible. 28. The regiment commanded by Colonel López sacked several towns, capturing an immense booty, which was afterwards distributed among the soldiers. 29. The Spanish caravel "Victoria" was the first ship which went round the world. She left Spain on Sept. 20, 1519, and returned on Sept. 6, 1522. 30. The Emperor Charles V. granted to Sebastián del Cano, the last commander of the "Victoria," an annual pension of 500 ducats and a coat of arms commemorating the services he had rendered to Spain. Cano did not always remember the loyalty due to the memory of his unfortunate admiral, Fernando de Magallanes. 31. The appeal to brute force, which we call war—Novikow writes—is always a degradation, a retrogression into the animalism that demoralises the victors as much as the vanquished. 32. In all nations there are, and will probably always be, a certain number of men whose lives only have for (their) object to make as much money as may be possible. 33. When the blind leads the blind, both fall in the ditch. 34. The aim of Art, Ruskin says (*dice*), is as serious as that of all other beautiful things—as that of the blue sky and the green grass, the clouds and the dew.

Continued

GERMAN

Continued from page 3028

By P. G. Konody and Dr. Osten

LIX. Comparison of Adjectives (continued from LV). In the comparison of predicative adjectives and corresponding adverbs of manner (which are not subject to declension) the superlative is formed with am (contraction of an dem) and aufs (auf das). Some monosyllabic adverbs often add the suffix -ens (spät, late, spät-est-ens; früh, early, früh-est-ens, etc.). Examples: Der Vogel fliegt schnell, the bird flies quickly; der Vogel fliegt schneller, am schnellsten, or

aufs Schnellste. Die Sache ist aufs Beste erledigt, the matter is settled in the best way. The adverbs bald, soon, early, and gern, willingly, gladly, form the comparison irregularly:

1. bald, 2. eher, 3. am ehesten.
1. gern, 2. lieber, 3. am liebsten.

1. The comparative of inferiority is formed with the comparatives weniger or minder, less, and nicht so . . . . als, not so . . . . as, which, of course, precede the adjective, adverb, or participle: Die Linde ist schattig, die Pappel ist weniger schattig (or nicht so schattig) als die Linde, The lime-tree is shady, the poplar is less shady than (not so shady as) the lime-tree.

The degree of mutual qualities may also be compared by mehr . . . . als, more . . . . than, and weniger . . . . als, less . . . . than: Das Haus ist weniger hoch, als es breit ist, The house is less high than it is wide.

2. The superlative is generally used with the definite article. The comparative may be used with the indefinite article, but not the superlative: ein jüngerer Sohn, a younger son; der jüngste Sohn, the youngest son.

The definite article is dropped in the form of the English possessive or Saxon genitive, which the German language has borrowed from the English: Die größte Tat Nelsons, the greatest deed of Nelson; but: Nelsons größte Tat, Nelson's greatest deed. The article is also dropped in several adverbial genitives like bestenfalls, in the best case; schlimmstenfalls, in the worst case, etc.; and in names of materials in advertisements, as: bestes Öl, best oil; feinste Seife, finest soap, etc.

The indefinite article is sometimes employed with the superlative if the superiority expressed is absolute. The superlatives allerliebst (in the sense of "most charming") and letzt (last) are absolute, and can therefore be used with the indefinite article: ein allerliebstes Mädchen, a most charming girl: ein letztes Mittel, a last means, etc. The plural is, of course, formed without article: allerliebste Mädchen.

3. As in English there are in German several adjectives which, owing to their definite nature, admit of no comparison whatever. Among them are those which denote certain geometrical forms and materials. A three-cornered object naturally cannot undergo any comparison of superiority, as a higher or lower degree of this quality is excluded: Eisern, of iron; golden, golden; silbern, of silver; steinern, of stone; drei'eckig, triangular; achtzigjährig, eighty years old; künftig, future; doppelt, double; ein-, zwei-, mehrsilbig, mono-, dis-, multisyllabic; and similar words, of which the positive already expresses the only and ultimate degree of quality. Leer, empty, and voll, full, do not belong to this group, as they admit relative comparison: a hall, for instance, may be emptier or fuller than another.

LX. Superlative Formed by Circumlocution. The superlative formed with am is used relatively (comparatively) with predicative adjectives and adverbs: Am besten ist das Brot, wenn es nicht zu frisch ist, The bread is best when it is not too new. Die Kinder sind fleißig, wenn sie allein sind, aber am fleißigsten im Bei'sein des Lehrers; The children are diligent when they are alone, but most diligent in the presence of the teacher.

1. The superlative formed with aufs is generally used adverbially and absolutely, without comparison, thus denoting a very high absolute degree of a certain condition: Ich wurde aufs Beste empfangen, I was received in the best way; ich war aufs Schlimmste gefaßt, I was prepared for the worst; er war aufs Höchste überrascht', He was surprised in the highest degree.

2. Adverbial superlatives with the root-form -st are usual with adjectives ending in -ig and -lich (generally in the *absolute* sense) denoting politeness, devotion, etc.: an'gelegentlich, concernedly, urgently, pressingly, angelegentlich-st; ehr'erbietig, reverentially, ehrerbietig-st; höflich-st, politely, ich bitte höflich-st, I beg most politely; sagen Sie mir gefäl'lig-st, Will you kindly tell me; zeigen Sie mir gütigst, Will you kindly show me, etc. But besides these there are some adverbial superlatives with -st, which are used in a relative sense: Bringen Sie mir möglich-st schnell, Bring me as quickly as possible; sie gab mir die mindest schöne Rose, She gave me the least beautiful rose, etc.

3. The adverbial superlative formed with -ens is generally used in an absolute sense: ich danke Ihnen schönstens (or bestens), I thank you very much; but never ich danke Ihnen herzlichstens, I thank you most heartily, as herz-lich is dissyllabic and belongs to the group of adjectives ending in -lich which take the root-form of the superlative with -st: herzlich-st.

4. Several adverbial superlatives with -st and the prefix zu are used relatively, the latter being sometimes written separately: zu höchst, highest; zu tiefst, lowest; and sometimes contracted with the superlative: zuerst', firstly; zuletzt, lastly; zumeist, mostly.

5. Several adverbs of place have corresponding attributive adjectives, which are used adverbially in the superlative.

Positive Adverb		*Attributive Adjective*		*Superlative Adjective used Adverbially*	
außen	out, on the outside	äußer	outward	äußerst	utmost, extreme
innen	within	inner	inner, intrinsic	innerst	inmost, innermost
oben	above, overhead	ober	upper, higher	oberst	uppermost, highest
unten	below, beneath	unter	under, below	unterst	lowest, undermost
(hie)nieden	down, below	nieder	low, lower	niederst	lowest
hinten	behind	hinter	behind, after	hinterst	hindermost, last
vorn	before, in front	vorder	fore, front	vorderst	foremost
mitten	in the midst, in the middle	mittler (mittel)	middle, mean	mittelst	midst, middlemost

LXI. Irregular Verbs, some combining strong and weak elements, some with irregular inflections. In the table below, rennen, to run, is conjugated with sein.

Infinitive		Present Tense	Imperfect *Indicative*	Imperfect *Subjunctive*	Imperative	Past Participle
bringen	to bring	ich bring-e, -st, -t	ich brachte	ich brächte	bring(e)	gebracht
dünken	to seem, appear	es dünkt	es däuchte	es däuchte	dünke	gedäucht
dürfen	to have permission, may	ich darf, darfst, darf; wir dürfen, dürft, dürfen; subj.: ich dürfe	ich durfte	ich dürfte	—	gedurft
können	to be able to, can	„ kann, -st, kann; wir können, könnt, können; subj.: ich könne	„ konnte	„ könnte	—	gekonnt
mahlen	to grind	„ mahl-e, -st, -t	„ mahlte	„ mahlte	mahl(e)	gemahlen
mögen	to be able, like, wish	„ mag, -st, mag; wir mögen, mögt, mögen; subj.: ich möge	„ mochte	„ möchte	—	gemocht
müssen	to be obliged, must	„ muß, -t, muß; wir müssen, müßt, müssen	„ mußte	„ müßte	—	gemußt
salzen	to salt	„ salz-e, -est, -t	„ salzte	„ salzte	salz(e)	gesalzen
sollen	to be obliged, shall, ought	„ soll, -st, soll; subj.: ich solle	„ sollte	„ sollte	—	gesollt
spalten	to split	„ spalt-e, -est, -et	„ spaltete	„ spaltete	spalt(e)	gespalten
wissen	to know	„ weiß, -t, weiß; wir wissen, wißt; subj.: ich wisse, -est, -e	„ wußte	„ wüßte	wisse	gewußt
wollen	to be willing, will	„ will, -st, will; wir wollen, wollt, wollen	„ wollte	„ wollte	wolle	gewollt
denken	to think	„ denk-e, -st, -t	„ dachte	„ dächte	denk(e)	gedacht
brennen	to burn, scorch	„ brenn-e, -st, -t	„ brannte	„ brennte	brenn(e)	gebrannt
kennen	to know	„ kenn-e, -st, -t	„ kannte	„ kennte	kenn(e)	gekannt
nennen	to name	„ nenn-e, -st, -t	„ nannte	„ nennte	nenn(e)	genannt
rennen	to run	„ renn-e, -st, -t	„ rannte	„ rennte	renn(e)	gerannt
senden	to send	„ send-e, -est, -et	„ sandte also sendete	„ sendete	send(e)	gesandt also gesendet
wenden	to turn	„ wend-e, -est, -et	ich wandte also wendete	„ wendete	wend(e)	gewandt also gewendet

EXERCISE 1. Insert the missing verbs:

Der Müller . . . . . . das Korn. Der Künstler hat
The miller grinds the corn. The artist has
das Bild . . . . . . Hast du den Kaffee . . . . ?
painted the picture. Have you ground the coffee?
Wenn ich nur mit euch gehen . . . . . ! Er . . . .
If I only could go with you! He must
heute gehen. Das Haus . . . . . Der Vater . . . . . .
go to-day. The house burnt. The father bought
die Geschenke für die Kinder.
the presents for the children.

EXERCISE 2 (*a*). Change the following comparatives into positives and superlatives:

Ich werde lieber zu Ihnen kommen. Es ist kühler
I shall prefer to come to you. It is cooler
im Garten. Er veranstaltete Alles besser.
in the garden. He arranged everything better.
Unsere Pferde liefen schneller. Die Rose roch
Our horses ran faster. The rose smelt
süßer. Er zielte genauer.
more sweetly. He aimed more precisely.

(*b*). Change the following comparatives into superlatives:

Er war ein jüngerer Sohn der Familie. Wir waren
He was a younger son of the family. We were
schlechtere Schüler in unserer Klasse.
worse pupils in our class.

(*c*). Change the following sentences into the form of the English possessive:

Der siegreichste Feldzug Napoleons.
The most glorious campaign of Napoleon.
Die schönste Zier des Menschen ist die Bescheidenheit.
The most beautiful adornment of man is modesty.
Das edelste Tier des Waldes ist der Hirsch.
The noblest animal of the forest is the stag.

(*d*). Insert the missing superlative suffixes:

Ich danke Ihnen best . . . . Ich danke Ihnen
I thank you [in the best way]. I thank you
herzlich . . . . . Grüßen Sie ihn schönst . . . .
most heartily. Give him my kindest regards.

KEYS TO EXERCISES IN EXAMINATION PAPER IN PAGE 3028

EXERCISE 1 (*a*). Der Tisch ist breiter. Das Seil ist dicker. Der Wein ist feiner. Die Rose riecht herrlicher. Wir kauften schönere Blumen. Er sah trauriger aus. Der Himmel ist düsterer. Der Baum ist kahler. Das Schloß war loser. Mein Pferd ist edler. Mein Pferd ist von edlerer Abstammung. Er sandte mir einen flinkeren Boten. Ich sah ein schlankeres Mädchen. Die Kerze brannte heller. Mein Papier ist weißer, und Ihres ist gelber. Nettere Leute findet man selten.

(*b*). *Comparative:* Das Pferd läuft schneller. Die Sonne Italiens scheint heller. Ich wohne näher.

Der Ton klingt reiner. Das Kind lernt fleißiger. Der Ballon steigt höher.

Superlative: Das Pferd läuft am schnellsten. Die Sonne Italiens scheint am hellsten. Ich wohne am nächsten. Der Ton klingt am reinsten. Das Kind lernt am fleißigsten. Der Ballon steigt am höchsten.

(*c*). Dieses Kind ist das eitelste (or am eitelsten). Die Straße war die ebenste (or am ebensten). Die Gesellschaft war die fröhlichste und heiterste (or am fröhlichsten und heitersten). Der tiefste Brunnen war auch der breiteste (or am breitesten). Man muß am vorsichtigsten sein, wenn etc. Der Turm ist der höchste (am höchsten). Das höchste Haus kostet am meisten. Ich habe das beste Pferd gekauft. Der edelste Wein schmeckt am besten.

(*d*) Ich bin so groß wie du. Ich bin größer als du. Sie sind so liebenswürdig wie Ihre Schwester. Sie sind liebenswürdiger als Ihr Bruder. Dieser Schüler ist weniger fleißig als jener, obgleich er so alt ist wie er. Das Haar des Mädchens war licht wie ein Kornfeld. .... lichter als ein Kornfeld.

Exercise 2 (*a*). Ich war der Fünfzehnte in der Reihe. Der Offizier las zuerst den dritten Namen und dann den achten. Es war am einundzwanzigsten Mai Auf welchen Tag der Woche fällt der erste April?

(*b*). Ein halb; ein Drittel; ein Viertel; ein Fünftel; ein Sechstel; ein Siebentel; ein Achtel; ein Sechzehntel; ein Zwanzigstel; ein Dreißigstel: ein Vierzigstel. $1\frac{1}{2}$ $4\frac{1}{2}$, $3\frac{1}{2}$, $5\frac{1}{2}$, $2\frac{1}{2}$.

Continued

FRENCH

Continued from page 3022

By Louis A. Barbé, B.A.

III. From the Past Participle are formed all the Compound Tenses by adding it to the respective tenses of the auxiliary *avoir* or *être*.

Donné	Fini
j'ai donné	*j'avais fini*
Reçu	Vendu
j'aurai reçu	*que j'aie vendu*

IV. From the Present Indicative the Imperative is formed by omitting the personal pronouns. In the first conjugation the final *s* of the second person singular is dropped. The imperative has no third persons of its own, but borrows those of the subjunctive:

	Indicative.	Imperative.
1.	*tu donnes*	*donne*
	nous donnons	*donnons*
	vous donnez	*donnez*
2.	*tu finis*	*finis*
	nous finissons	*finissons*
	vous finissez	*finissez*
3.	*tu reçois*	*reçois*
	nous recevons	*recevons*
	vous recevez	*recevez*
4.	*tu vends*	*vends*
	nous vendons	*vendons*
	vous vendez	*vendez*

Exceptions:

1. Third Conjugation:

Indicative.	Imperative.
avoir	
tu as, thou hast	*aie*
nous avons	*ayons*
vous avez	*ayez*
savoir	
tu sais, thou knowest	*sache*
nous savons	*sachons*
vous savez	*sachez*

2. Fourth Conjugation:

Indicative.	Imperative.
être	
tu es, thou art	*sois*
nous sommes	*soyons*
vous êtes	*soyez*

V. From the Past Definite the Imperfect Subjunctive is formed, by changing *s* of the second person singular into *sse, sses, t, ssions, ssiez, ssent*. In the third person singular, the vowel immediately preceding the final *t* takes a circumflex accent:

tu Donna-s	*tu* Fini-s
que je donna-sse	*que je fini-sse*
que tu donna-sses	*que tu fini-sses*
qu'il donnâ-t	*qu'il finî-t*
que nous donna-ssions	*que nous fini-ssions*
que vous donna-ssiez	*que vous fini-ssiez*
qu'ils donna-ssent	*qu'ils fini-ssent*
tu Reçu-s	*tu* Vendi-s
que je reçu-sse	*que je vendi-sse*
que tu reçu-sses	*que tu vendi-sses*
qu'il reçû-t	*qu'il vendî-t*
que nous reçu-ssions	*que nous vendi-ssions*
que vous reçu-ssiez	*que vous vendi-ssiez*
qu'ils reçu-ssent	*qu'ils vendi-ssent*

1. **Special Remarks.** All propositions but one require the verb which follows them to be in the infinitive. The single exception is *en* (in) which takes the present participle after it:

Il joue au lieu de travailler, He plays instead of working; *Il me regarda sans rien dire,* He looked at me without saying anything; *Après avoir lu la lettre il me la donna,* After having read the letter he gave it to me; *Les ouvriers travaillaient en chantant,* The workmen sang as they worked; *Elle nous regarda en souriant,* She looked at us smiling.

2. In English, "one," "ones" frequently take the place of a noun after an adjective. In French, there is no such construction, and the adjective alone must be used:

There are two books on the table, a large one and a small one, *Il y a deux livres sur la table, un petit et un grand;* Take the good ones and leave the bad ones, *Prenez les bons et laissez les mauvais.*

3. An adverb must never be placed between subject and verb. Its usual place is after the verb in a simple tense, and between the auxiliary and the verb in a compound tense:

I never see him, *Je ne le vois jamais;* He has never spoken to me, *Il ne m'a jamais parlé.*

4. An "if" clause must have its verb in either the present or the imperfect indicative.

With an "if" clause in the present, the "result" clause must be either in the present or the future indicative, or in the present imperative. With an "if" clause in the imperfect, the "result" clause must be in the conditional:

S'il est ici, il doit nous voir, If he is here, he must see us; *S'il est ici, il nous verra,* If he is here, he will see us; *S'il vient demain, nous le verrons,* If he comes to-morrow, we shall see him; *S'il est ici, qu'il vienne nous parler,* If he is here, let him come and speak to us; *S'il était ici, il viendrait nous parler,* If he were here, he would come and speak to us.

5. *Assez,* enough, always precedes the adjectives which it modifies:

Le plus petit ennemi est toujours assez grand pour être dangereux, The smallest enemy is always big enough to be dangerous.

Exercise XXIII.

Vocabulary

le bout, end, tip
la cause, cause
le charançon, weevil
le chef-d'œuvre, masterpiece
la chenille, caterpillar
la chose, thing
le commencement, beginning
la contrariété, vexation
le crime, crime
le défaut, defect
la dent, tooth
envie (f), envy
éléphant (m.), elephant
enfant (m.), child
ennemi (m.), enemy
ennui (m.), annoyance
la famille, family
la fluxion de poitrine, inflammation of the lungs
la haine, hatred
importance (f.), importance
insecte (m.), insect
la jalousie, jealousy
le laboureur, husbandman
le mal, ailment
la maladie, illness
le mensonge, falsehood
la moisson, harvest
la mouche, fly
le nez, nose
le panier, basket
la perte, loss
le point, spot, speck
la postérité, posterity
la progéniture, progeny
le rhume, cold
la ruine, ruin
la sauterelle, grasshopper, locust
la ténuité, tenuity, minuteness
le tour, turn
la treille, vine-stalk
la vanité, vanity
la verrue, wart
le vice, vice
le voisinage, neighbourhood
le voisin, the neighbour
le voleur, thief

continuel, continual
dangereux, dangerous
durable, lasting
imperceptible, imperceptible
implacable, implacable
indifférent, indifferent, of no consequence
indulgent, indulgent
innocent, innocent
insupportable, unbearable
mortel, deadly
permanent, permanent
petit, little, slight
pourri, rotten, bad (of fruit)
seul, alone, only
vilain, ugly, nasty

arriver, to arrive, come
causer, to cause
coûter, to cost
craindre, to fear
dépouiller, to despoil, plunder
gâter, to spoil, decay (of teeth)
mépriser, to despise
négliger, to neglect
réformer, to reform, cure

à cause de, because of
assez, enough
aujourd'hui, to-day
bien, very
bien de (*des*), many
bientôt, soon
contre, against
d'ailleurs, moreover
demain, to-morrow
en herbe, in the blade
en outre, in addition
ensuite, afterwards, then
malheureusement, unfortunately
presque, almost
parmi, amongst
quand, when
quelquefois, sometimes
sans, without, but for
seulement, only
sur nos gardes, on our guard
toujours, always.

Those who despise small defects are very wrong. The smallest enemy is always big enough to be dangerous. It is not elephants that cause the loss of harvests and the ruin of husbandmen; it is locusts and little caterpillars, when the corn is in the blade; weevils and other imperceptible insects, when it is ripe. It is not big robbers only that despoil the vine-stalk and the orchard of their fruit; it is little ones also, sparrows and even flies. Without being deadly, little ailments are sometimes enemies as unbearable as the big illnesses of which we are afraid. It is almost always through little neglected ailments that the serious (great) ones come. To-morrow the little cold of to-day will perhaps be inflammation of the lungs. But for little defects there would not be any vices. Moreover, a little defect is not a slight thing, and where there is one, there will never be any masterpiece. A wart is not very big, but if you have it on the tip of your nose, it will be for you a continual cause of annoyance and of vexation. A small defect is never of slight importance if it is permanent. What is lasting is never slight. Moreover, a little defect is always the beginning of a big one; vices themselves are the children of little defects. The little defect will soon be great; where there was one there will soon be several. A little defect is never alone. It always has a family. If it is not for itself, it is for its posterity that it is to be feared. You have a tooth that has a little black spot. It is nothing; but, if you neglect it, it will soon be the whole tooth that will be decayed. After that one it will be the neighbour (f.), and then the neighbour's neighbour, and the little black speck that you have neglected will have cost you several teeth. If there is a bad plum in a basket of plums, all the plums will soon be bad. The neighbourhood of a little defect is never of no consequence. Vanity seems to be a slight defect; but it is a slight defect that has a very nasty progeny. It has for (its) son, falsehood, which, unfortunately, is not its only child. It has, in addition, two daughters, who are jealousy and envy. Amongst their posterity they will have hatred, which will, in (à) its turn, be the mother of many crimes. It is because of their very minuteness that little defects are so dangerous. If they did not look so innocent we should be afraid of them, we should be on our guard against them. Be indulgent towards (à) the little defects of your friends, if you are not in a position to cure them; but towards yours, which are always under your hand, be implacable.

Continued

A General Survey of the Duties of Servants. The Butler. The Footman.

THE CARE OF THE HOME

The comfort of a household is indissolubly associated with the character and competence of the domestic servants. This being the case, it is not surprising that the mistress attaches the greatest importance to the evidence of the past career of the servant she engages. It is a serious matter to introduce into a household a person of whom little is known, who cannot produce evidence of good character and a certain amount of skill from those with whom he or she has been previously associated.

In engaging a servant the mistress should be on the look-out for certain moral characteristics which are most important. On the other hand, those who wish for success in the capacity of domestic servant will do well to consider the value of such qualities, and endeavour to acquire and exercise them.

Cleanliness of person and habits of neatness and method in general cannot be overrated. Good work cannot be done without neatness and method, and untidy habits and uncleanly utensils double the work of the servant and give much annoyance to the mistress. Personal neatness is also of great importance. The neat print dress and cap and apron of the maidservant and the livery of the manservant, if properly cared for, contribute greatly to their satisfactory appearance; and with due attention to such details as neat hair, and personal cleanliness, the dress of the domestic servant is at once becoming, suitable, and by no means unattractive.

Clothing. In the matter of clothing the master is not ordinarily bound to provide his servants with clothing, unless some special agreement to that effect has been made. In some cases a particular livery is given to menservants, and in individual cases it becomes the absolute property of the servant after a certain length of time. In the case of maidservants some mistresses prefer to provide them with dresses of a particular colour and material; and in small households, where only one or two maids are kept, some mistresses will invest in large and particularly strong housework aprons for wear during the performance of rough and dirty work. Strong gloves should also be provided for the servants to wear when cleaning grates, polishing silver, and on other occasions when without such special protection the hands would become unnecessarily dirty.

The Giving of Testimonials. In order to protect a mistress when engaging a new servant, it is customary for a written statement called "a character" to be given by a previous employer. A mistress is, however, under no legal obligation to give the servant a character. It is, nevertheless, customary to do so, and refusal is generally very prejudicial to the servant concerned, implying, as it does, that the late employer is unable to testify to his good qualities. If a mistress consents to give a character, she must be careful to state the truth. There must be no exaggeration either of the servant's qualities or imperfections. The "reference" should be an unprejudiced statement of the servant's characteristics, and should give a correct impression of the servant's abilities. Such a statement, so made, whether by word of mouth or in writing, is held in law as "a privileged communication," and the employer making such "privileged communication" does not render himself liable for slander or libel. This security of the master holds good even if the statements made in giving the "character" be untrue, unless it can be proved that the statement was made "maliciously."

A master or mistress who wilfully gives a false character incurs a grave liability. Should the new employer incur loss or injury as the result, the mistress giving the false character renders herself liable. If the new employer finds that the servant does not deserve, or in some way forfeits, the good character given previously, the new employer should not allow others to be imposed on by a false character. But the utmost care must be taken, in adding any disparaging remark to such a statement, that nothing but the truth be added, and that *without malice*.

It is an offence against common law to forge a character in order to deceive and obtain a situation by false pretences. Heavy penalties are incurred by those who "falsely personate a master or mistress," or who wilfully make misstatements with regard to length of service, or the capacity in which the servant has been hired; or who alter or efface any word or other detail given in a character by a former master or mistress.

When a Servant may be Dismissed. If a servant is engaged temporarily for some definite period—say, a week or a month—no notice need be given her, as she will leave at the expiration of her engagement. In ordinary cases of domestic servants it is customary—and the custom is recognised by law—to give one month's notice, or a month's wage in lieu of notice.

If a domestic servant is guilty of wilful disobedience to a lawful order she renders herself liable to dismissal without notice, but trifling acts of disobedience are not sufficient to justify such summary dismissal. Misconduct is the most usual cause of his or her dismissal without notice. If a servant be guilty of habitual drunkenness, or drunkenness even on one occasion, which unfits him to execute his duty; if the servant be guilty of immorality, violent conduct, or theft, instant dismissal is warrantable. Gross and habitual negligence of duties may meet with similar treatment; while a servant who is quite incompetent to perform the duties undertaken may be dismissed without notice, as he cannot perform his part of the contract.

If the master or mistress denies proper food to the servant, or exposes the servant to unnecessary risk, the servant may leave her situation at once. Also, if infectious disease breaks out in a house, the servant may (but there may be exceptions to this) leave without giving notice. If the servant leaves her situation in this way, and

is justified in doing so, she may claim her wages up to date, and, possibly, compensation too.

Large Households. In a large household the four chief servants are the housekeeper, the butler, the lady's-maid, and the valet. They take their meals together, and their duties bring them more in contact with their master and mistress than the work of any of the other servants. Thus, it is important for these upper servants to be particularly careful in their manner and bearing towards their employers, to be invariably respectful in their presence, and unflinchingly loyal in their absence. The housekeeper has abundant opportunity of influencing the women-servants of the household for good, who will all take their cue from her.

The butler is similarly responsible for the tone prevalent among the menservants. One of his duties will be that of securing faithful service from the under menservants.

In their bearing towards their employers the manner of upper and lower servants should entirely coincide. The most perfect civility and politeness is accepted as an essential characteristic in the execution of duty. The servant should never sit down in the presence of the master or mistress unless expressly told to do so. The servant should also be careful not to offer an opinion unless invited to do so. If this attention to manner and deportment is observed carefully by the servants, the master and mistress will be spared the necessity of making any unpleasant complaint on this score, and the servant will escape the disagreeable necessity of listening to it.

Board Wages. If for any reason it becomes necessary for the servant or servants to be left at home while the rest of the family are away, it is usual to place them on what are termed board wages. This is a sum of money paid in addition to ordinary wages, and intended to be spent on the food and other necessaries to which the servant would be entitled if the master were at home. The actual sum paid will vary according to the style of household in which the servant is engaged, and it will also vary with the sex of the servants for whom such provision is being made. Thus, a minimum sum paid to a maidservant as board wages would be 10s. a week in addition to her ordinary wages, the amount being increased in a wealthier establishment, or when paid to a man.

In a large household where many servants are left on board wages, each will be paid his or her allowance individually, but as a general rule the servants will add the small independent sums together for current expenses. Under this arrangement, by good management, each servant will live exceedingly well, and a surplus will probably be left over from the total sum of board-wage money, which at the end of each week can then be divided among them.

We will now consider in detail the various duties of each member of the servants' hall.

THE BUTLER

The butler is the chief manservant in the household. All the menservants whose duties are executed indoors live in the house; those whose duties are concerned with outdoor work, such as the gardeners and the chauffeur, live out of the house. The head-gardener and chauffeur are generally each given the use of a small house or cottage, either on the estate or in the vicinity, this being in addition to their ordinary wages. Certain indoor servants have special privileges connected with their duties. For example, the valet will have little expense connected with his own wardrobe, since he has no livery, and can therefore wear out his master's discarded clothes.

The butler, together with the housekeeper, takes precedence of all the other servants, and his duties are very responsible ones. Besides being expected to superintend the other menservants, and to see that their duties are properly executed, he has charge of all the valuable articles in daily use, and he is entirely responsible for the management of the wine-cellar. It is obvious that the moral integrity of the butler should be above suspicion.

The Butler's Duties when Waiting at Table. The butler waits at table during breakfast, assisted by the footman. He is responsible for the proper arrangement of the table and for the serving of the breakfast dishes. He is also expected to see that the china in use at the meal is clean and the silver properly polished. After breakfast he will clear the table, taking away the plate, which is under his care. At luncheon the arrangement of the table falls to his share, as well as the waiting. At this meal the butler usually waits single-handed, as the footman is engaged in other duties. The butler's most onerous duties are performed at dinner-time. Before dinner is served he has to supervise the laying of the table, and see that the flowers, table-centre, and table decorations are well arranged. He will also place the silver on the table, and see that every necessary article is in readiness.

When the dinner is ready, he brings in the first course, and announces in the drawing-room that dinner is on the table. He then stands near the dining-room door as the family come into the room, and closes it after the last to enter. When the diners are all seated he approaches the table. In some houses the master serves many of the dishes which are, in such a case, placed in front of him. The butler stands behind his chair, removes the covers, and hands them to the other servants in waiting to carry out. If, on the other hand, the dishes are served at the side-table, the duty of dispensing them will devolve on the butler. He will serve the soup, and then, if wine is taken, cross to the sideboard to pour out the sherry and madeira taken after that course.

The Serving of Wine, and Carving. When the first course is ended, the butler rings the bell to warn the cook that the second course may be served. He then collects the plates and dishes of the first course, hands them to the other servants to remove, takes the second course from them, places it on the table, and, after removing the covers, returns to the sideboard to dispense the wines. If the joints are served at the side-table, it will be the butler's duty to carve them; he should therefore be an expert carver. Of course, at a very large dinner-party help will be needed for this part of the work, but in ordinary cases a well-trained butler will carve sufficiently quickly to serve everyone present at the table with but little delay. When the dinner is finished, the butler, assisted by the footman, removes the wineglasses and extra silver and cutlery, and sets the table for dessert. He places the finger-bowls and fruit knives and forks before each guest, and the fruits and sweetmeats on the table. He then hands round the various dessert dishes, and stands behind his master's chair to hand the wines. He sees that the room is in order, that the fire, if lighted, is replenished, that the lights are in order, and then,

at a signal from the master, the butler and the footman leave the room.

Care of the Wine-cellar. While the guests are in the dining-room he goes to the drawing-room, arranges the windows, makes up the fire, tidies the hearth, and sees that the lights are in order. He then returns to his pantry. While the footman is clearing the table and cleaning the plate and glasses, the butler must be in readiness to answer the bell. When the guests are again assembled in the drawing-room, he will, either alone or assisted by the footman, serve the coffee. This is brought in on a tray, together with hot milk, cream, and sugar, and is handed to the guests in turn, each person pouring out his or her own portion, and adding sugar and cream.

In brief, the butler's duty is to be in attendance at every meal, including that of tea, to see that the table is properly set, and that the service is as it should be in every way.

The Butler's Duties at Night. After the family have retired it is his duty to go the round of the house, seeing that all the doors and windows are safely bolted and barred, that all lights are extinguished, and that the fires are safe. He must be particularly careful to see that the wine-cellar is locked, and that the plate and valuables for which he is responsible are safely locked up for the night. If the master of the house has no valet, the butler may be called upon to perform some of his duties, but these will not be arduous, and need not interfere with the performance of his regular duties.

The butler must see that the wine-cellar is kept in a clean and proper condition. He should be familiar with the qualities and treatment of the various wines, and so be able to advise his master as to the best choice. The butler must know what is the proper treatment of the various wines under his care, and he should spare himself no pains in his endeavour to secure for his master the reputation of "keeping a good wine-cellar."

Although the wines are often purchased ready bottled, it is sometimes the butler's duty to fine and bottle them, in which case he should be familiar with the process. A portion of wine is drawn off from the cask, mixed with the whites of four eggs, and thoroughly stirred. This mixture is then returned to the cask by the bunghole, together with the rest of the wine previously withdrawn. The contents of the cask must be stirred round by means of a wooden rod inserted through the bunghole. All bubbles rising to the top should be removed when the mixing is finished, the bunghole plugged, and the cask left to stand for three or four days. Wine so treated will fine 12 gallons of port or sherry.

Some butlers prefer other clearing ingredients than the whites of eggs. Small pieces of isinglass or gelatine, cut into tiny fragments and dissolved in the withdrawn wine, may be used instead.

Bottling Wine. This is an important operation. A small hole is bored at the bottom of the cask, a gimlet being used for the purpose. The bottles are in turn placed under the hole, and a strainer is used to prevent "grounds" from entering the bottle. As the cask becomes nearly empty a piece of muslin placed over the strainer will filter the wine more effectually.

The corks should be soaked in hot water and then squeezed dry. The bottle to be corked is placed in the bottling-boot, which is strapped on to the knee of the person doing the corking; the cork is then forced in with several smart blows from a broad, wooden mallet. The corks should then be sealed, or the heads of the bottles dipped into quicklime or petroleum to keep insects away.

The bottles of wine should be carefully counted, and a written record of them kept by the butler. The bottles of wine are laid on a stand in layers. The alternate layers will be with either head or bottom of the bottles outwards, and between the layers there will be sawdust or straw.

The Cellar-book. A careful butler will wash the empty wine-bottles and keep them carefully sorted. This is a great saving of trouble when bottling is in full swing. If the wine is purchased ready bottled, it will not be so necessary to keep the different kinds of bottles sorted, but whenever a fresh supply of wine is bought the butler will do well to return a corresponding number of bottles to the merchant.

The casks should be well rinsed with boiling water and kept scrupulously clean. Should there be any trace of a sour or musty smell, the cask must be cleansed with lime and boiling water, and well rinsed and dried before being used again.

The butler should also keep a "cellar-book," in which to make an entry of every bottle used.

The butler's wages will vary with different localities, ranging from £60 to £80 per annum.

THE FOOTMAN

The duties of the footman vary considerably, according to whether he works single-handed or whether there are other footmen working under him. Where others are kept, the head-footman works in conjunction with the butler. He helps in, or supervises, the laying of the table for meals, and in the serving of afternoon tea and of coffee after dinner. During meals he waits at table, under the butler, taking precedence of the other footmen. In the afternoon he should be in readiness to answer the front-door bell. If a valet is not kept, he may be required to give a certain amount of personal attendance on his master.

If there are visitors in the house who have not brought their own valets, he will probably be called upon to give them similar personal attendance. He will have no responsibility with regard to the washing of glass and the polishing of plate beyond that of seeing that the under-footmen carry out such duties efficiently.

Duties of the Second and Third Footmen. The second footman has more onerous duties than those of the head-footman, whom, in every way possible, he is called upon to assist. He may occasionally wait in the hall if many visitors are expected. His table duties include assistance in waiting, and in the washing of the glass and silver used in the dining-room. In the afternoon he may be called upon to go out with the carriage if the ladies of the house wish to pay calls. In this case he should see that they are seated comfortably, and the rugs and wraps adjusted satisfactorily. He should place the umbrellas or sunshades in the carriage or the automobile, and take from his mistress her order to the coachman as to the direction of the drive. He will then close the door, and mount to his seat beside the coachman. When the house at which the mistress intends to call is reached he should descend from his seat, ring, and find out if the ladies are at home, telling his mistress and awaiting her orders.

The third footman is responsible for the heavier, dirty work, such as cleaning the knives and boots, and filling the coal-scuttles—in fact, carrying out the duties of a houseboy, if one is not kept.

THE FORGING AND CUTTING OF FILES

1. FORGING BLANKS

2. ANNEALING FILE BLANKS IN THE FURNACES

3. HAND GRINDING

4. MACHINE CUTTING

5. SMOOTHING FINE FILES

6. HARDENING FILES IN BATHS OF MOLTEN LEAD

From photographs by courtesy of Messrs. Samuel Osborn & Co., Sheffield.

Instruments for Handicrafts — Chisels, Circular, Band, and Hand Saws, Files and File-Making Machines.

MAKING TOOLS

THE distinction between cutlery and tools cannot be stated in a brief covering phrase. The first is commonly understood to mean edged instruments, but the majority of tools, all those which are grouped as cutting tools, are also edged instruments. Again, scissors are classed as cutlery, but shears—which are magnified scissors—are tools. Table-knives are cutlery, but the carpenter's drawknife is a tool. Such anomalies might be multiplied. The correct distinction is that between edged instruments employed for general service and all instruments, whether edged or not, that are used in trades and handicrafts. These include not only cutting tools, chisels, gouges, axes, planes, saws, but files, hammers, pincers, and so on. It excludes, however, all those tools termed machine tools, which displace handicraft.

Much description previously given of the work of the cutler applies also to that of the toolmaker. The preparation and selection of the steel, the forging, hardening, tempering, grinding are substantially alike in both, though performed by different men in separate factories. We shall therefore avoid repetition by restricting the present account to work on tools that has not been covered by the previous article on cutlery. [See pp. 2910 and 3041.]

Composite Character of Tools. Nearly all edged tools, the smallest only excepted, are, like cutlery, of a composite character, comprising a body of wrought iron and a cutting edge of crucible steel. The joint between the two can be seen clearly in axes and adzes, in plane irons, in drawknives, in scythes, in planer-machine knives, and so forth. The more valuable material is economised, and the non-cutting body is not brittle, so that a double advantage is gained. The welding of the two portions is done at an early stage of the forging, and the two portions thus united are finished as one. In axes and drawknives the steel is let into a vee, and embraced on both flanks by the iron, but in plane irons and planer knives the two are welded face to face. The steel, however, is not continued beyond the working length or breadth, or farther than where the working life of the cutting instrument will terminate.

The Carpenter's Drawknife. In making a carpenter's common drawknife a bar of iron is taken, the ends are drawn down, and a slit is cut in the centre body, into which a piece of tool steel is welded. The whole body is then lengthened and thinned by drawing down to the section required, and the ends are tapered and bent to form the tangs. Hardening and grinding follow.

Socket Chisels. Socket chisels are made thus: a piece of sheet iron is cut, and rolled into a correct shape to form the socket. The chisel blade—of steel—has one end of its shank drawn down to fit in the small end of the cone. The two are then heated and welded. A rod is inserted in the socket, while the two parts are welded together between top and bottom dies. The ordinary chisels and gouges are drawn down and stamped in dies. Plane irons have the steel faces welded on by passing the two at welding heat between rolls.

Axes. Axes, as stated, are not made in solid steel, for that would be too expensive. Only the cutting edge is of steel, welded to the wrought-iron bodies. A plain billet or block of iron is taken and forged by thinning down in two places, leaving thicker metal at the centre and at the ends. The thinned metal forms the sides or flanks of the eye, the central metal the head, and the thick ends the body of the axe between which the strip of steel which is to form the cutting edge is to be welded. The blank is bent round, the steel inserted, flux dusted on, and the whole raised to a welding heat, and the joint closed by hammering. The blade is afterwards thinned down and spread out to the final shape.

The tempering of axes is an operation that has to be done with care. Hardening at a bright cherry-red precedes tempering. The axe is plunged into a tub of brine to within about half an inch of the eye, and moved about until it is cold. A small portion of the surface is polished with a piece of grindstone to permit the correct tint to be seen. It is reheated to a dark straw colour, and plunged into the bath. Some men draw to a blue colour, and lay the axe aside to cool.

Saws. Saws are made from crucible steel, first cast into an ingot, and afterwards treated according to the shape and size of the saws to be manufactured. The steel must be perfectly homogeneous, and of high tensile strength, yet tough and flexible enough to endure rolling and much bending. A good handsaw, for example, can be bent on itself so that the tip may nearly touch the handle. The ingots are hammered into slabs under a steam or other power hammer, and afterwards rolled to thickness, with an allowance for grinding. They are now annealed or softened, and trimmed with shears roughly into the ultimate shape in readiness for delivery to the saw-makers. From this stage follow variations in treatment with the kind of saw to be manufactured. These range through a score or two of different types and shapes, and hundreds of sizes. In general, the treatment is as follows.

Circular Saws. In making circular saws, plain circular discs of annealed steel first have the centre hole for the arbor punched in a press, or drilled. By means of this hole the saw is centred, and set up in a press in which the teeth are punched. This is done in a machine having an indexing disc for pitching the correct numbers of the teeth, a separate index being used for saws with different numbers of teeth. The punches are of the same shape and size as the tooth spaces. They vary in shapes, in angles, and in depths with every different type and size of saw. Afterwards the saws are hardened. A large circular saw is more liable to buckle—that is, for its surface to become bent out of a perfect plane—than any other kind is. From the hardening process to the sending out of the finished saw this is the most persistent evil to be overcome. In the hardening process the saw is first heated slowly and evenly in a gas reverberatory furnace. It is then laid on a grid-like plate, not smaller than the saw, and it is covered by another similar plate. The saw, while thus confined, is hardened in a tank of oil.

The saws come out practically without any warp, or camber, and are sent now to have the sides ground. Usually, though not invariably, both sides are being ground simultaneously. The saw is mounted on a horizontal arbor in the machine, which is designed for this work only. The stones are fed by a hand-wheel and toothed gears, across the faces of the saw. The wheels and the saw rotate in the same direction, but at different speeds, the saw running more slowly. The grinding begins at the outer edge, and proceeds inwards. Abundance of water is used to keep the plates cool. The saws are ground either of parallel thickness or hollow—usually hollow. Making the saw thinner towards the centre than at the outer edge is favourable to the clearance of the saw in its cut.

Grinding occupies only a few minutes, and the water prevents the temper from becoming drawn. Polishing follows in a machine with a pad charged with flour emery.

The saw now has to be set and sharpened, and the plate "blocked" or "tensioned." The first is done on automatic machines; the second is a hand process requiring a very high degree of skill. The explanation of this reveals one of the remarkable facts in the work of the circular saws.

Circular saws used for cutting wood run at such high velocities that unless the stiffness of the plate is regulated they never run truly, but wobble or wave from side to side in an undulating fashion. This happens frequently when a saw is driven so hard that heat is generated by the cutting. It would always occur if the saws were not "opened out" about the central area. If, in consequence of alternate heating and cooling, or by the action of centrifugal force, the rim of the saw becomes permanently expanded, it will not run true. It should be "slack" at the periphery, to allow something for stretching. A saw should be more "open" in the body for high speeds than for low, and for hard than for soft woods. When a saw is properly opened out, the central parts are not easily pushed out of the general plane if the saw is stood edgewise on the floor.

The hammering is done in concentric circles about midway between the rim and the centre. The degree of truth of the surface is tested with straight-edges. The effect of the hammer blows is to stretch or open out the metal at the part struck. Different hammers are used, round-faced and cross-pane, according to the nature of the lumps or ridges.

Circular Saws with Inserted Teeth. The solid circular saws for woodworkers are of the type upon which large numbers are made with inserted teeth. These were first adopted in order to retain the diameter of the saw, which is, of course, reduced by repeated re-sharpenings of teeth. A secondary advantage is that broken teeth do not matter, because they can be replaced. Broken teeth are objectionable in a solid saw. Of late years, also, with the enormous increase in the employment of circular saws for cutting iron and steel, the insertion of teeth permits of the use of expensive high-speed steel for the teeth, while retaining a comparatively soft and cheaper steel for the disc. The discs are treated similarly to those of solid saws, except so far as the teeth are concerned. Spaces have to be milled to receive the teeth. These are drop-forged, trimmed, ground, and sharpened, and finally inserted. A special kind of inserted tooth-saw is that in which a diamond is embedded in each tooth for cutting stone or marble. These have been made 100 inches in diameter, with 180 teeth and diamonds.

Bandsaws. From the manufacturer's point of view, as distinct from that of bench worker's, the bandsaws rank a good second to the circulars. Bandsaws were novelties in 1866, and they were then mere ribbons of about $\frac{3}{8}$ in. wide. Now saws are made 18 in. wide and 64 ft. long, and some have teeth on both edges to cut a log in both directions. Originally designed for going round curves, they are employed nearly as often now for straight cutting. They are commonly employed also for sawing iron and steel, and, like the circular saws, some have solid teeth and some inserted teeth.

The same processes essentially are gone through as for circular saws, modified by the difference in shapes. The oblong crude rough ingot contains the future bandsaw. It is first hammered until its length and width are about doubled, and is then finished by rolling. The first stage of rolling is done hot, the second cold, after which the blade goes into the saw-making department. The furnaces and the machinery used are different from those which are suitable for circular saws. All the work is done before the ends of the long blade are bent round and brazed to form the endless band.

The hardening is followed by tempering, which is more difficult than that of circular saws, because the bandsaw by the nature of its movements is peculiarly liable to develop a crystalline condition of the steel. As it passes round the wheels it is alternately being bent and straightened a hundred times or more every minute. Toughness is therefore of more importance than hardness, yet the steel must not be tempered so soft that the teeth will lose their edges rapidly. The saws are hardened and tempered by being drawn through a gas furnace into an oil tank, the movements being regulated automatically. Afterwards the blade is ground to thickness, the band being drawn along underneath the grindstone. The table is tilted in order to grind the blade thinner at the back than at the front, to enable the saw to clear itself in its cut.

The teeth are ground in a machine which carries the blade round under an emery wheel with a stop which arrests the movement during the short period when a tooth space is being formed. In the larger saws the teeth may be stamped out previous to the grinding. Afterwards the tensioning, has to be performed. This, however, is done usually in a machine, the blade being passed between rollers, the location of the rolling being varied according to whether it is too open or not sufficiently so. The result is also corrected finally by means of hand-hammers, just as it is performed by the men in charge of the saws when they buckle with service. The last stage is the scarfing of the ends to make a lap joint, and the soldering, followed by dressing of the joint, and final sharpening of the teeth.

Handsaws. The methods employed in manufacturing handsaws apply in general to those by which the cross-cut saws, back saws, compass saws, butchers' saws, and the like are produced.

The steel ingots are hammered and rolled to the gauge desired, and sheared into the suitable shapes and sizes for the classes and sizes of saw made, and the teeth are punched. Hardening and tempering follow. The saws are heated in an oil furnace, and placed edge downwards in the bath, oil being used for tempering, and the saws being held in clamps. Corrections of the blade are necessary to remove slight inequalities of surface produced by the hardening. This is done by hand hammering. Grinding follows as in other cases, on large stones. The best saws are ground tapered in two directions, being

thinner on the back than next the teeth, and thinner at the point than at the handle. The tensioning is the next stage, in which the metal is stretched by hammering, where necessary, along the edge or the centre. Final corrections are made both in blocking and in grinding and polishing. The teeth are then set and sharpened and the saw handled.

Files. Files are made in enormous numbers. They are used in nearly every trade by wood and metal workers. A big file-making works turns out several hundreds of tons in a year. It is an industry that has been almost wholly transformed from hand-cutting to machine-cutting during the last few years. Today, instead of men cutting the teeth singly with chisels, girls attend to machines that cut a thousand teeth, more or less, in a minute. As a result, apprentices are no longer taken for hand file-cutting. Sheffield and Warrington are the chief centres of the file-making industry in England. At one time much of the work was done at home by domestic workers, but it is now almost wholly performed in big factories.

The photographic illustrations are those of a large file-making works in Sheffield, that of Messrs. Samuel Osborn and Co., Ltd. This firm has three works engaged in making steel, including the wonderful Mushet brands, and in the manufacture of tools, drills, milling cutters, steel castings for all purposes from small to large, engaging, in all, the labours of about 1000 men and a large quantity of machinery. The files are manufactured at the Brookhill Works, but the steel is produced at the Wicker Works, and stocked at Brookhill. It is crucible steel, cast into ingots, and worked into bars of different sections by means of steam hammers and rolling mills. In this condition the bars are stacked in the warehouse in all sections required for the numerous sizes of files made. They are selected as wanted, and cut off in blanks or "moods."

The moods are heated in gas furnaces, and forged to shape under power hammers [1]. Formerly this shaping was done by the manipulation of the forger, but a growing practice at present is to produce the shape in dies or stamps. These are made in sets to suit the numerous sections and outlines required for the body—parallel, or tapered, or bellied, square, round, triangular, and so on—and to form the tang. Steam or other kinds of hammers are employed, the movements of which are controlled by a pedal.

After the forging, the blanks have to be annealed [2], which is done in furnaces, occupying about twenty-four hours. Grinding follows [3] on large stones about 5 ft. in diameter by 12 in. wide. The blanks are not done singly, but from eight to ten are arranged in a row. The files are kept cool by movement in a bath of water. Some shapes, such as half-rounds and rounds, are ground by hand. The tangs are also ground thus.

Cutting Files by Hand. File-cutting by hand, still performed to a small extent for very small and thin files, is done with a broad, stumpy chisel, struck with a hammer. The file blank is laid on a stake or anvil, the tang being directed towards the cutter. The end is held by a leather loop, which is pressed down by the right foot. The cutting begins at the point. The degree of coarseness of the cut is regulated by the force of the blow dealt, which throws up a burr or ridge, shallow or deep. The regularity of the cuts is controlled by setting the chisel by the burr. From sixty to eighty blows are delivered per minute. There are differences of inclination of the chisel for different kinds of files. For "rough cut" files the inclination is 12 deg. beyond the perpendicular; for "bastard" files, 10 deg.; for "second cut" files, 7 deg.; for "smooth cut" files, 5 deg.; and for "dead smooth" files only 4 deg. Files that are curved across their faces, as the round and half-round and the like, require a number of courses of cuts, eight, ten, and upwards, to complete them. When a file is turned over on its cut face, for the opposite face to be dealt with, it is laid on a plate of pewter or in a block of lead or tin, the softness of which does not blunt the teeth.

Machines for Cutting Files. At the works of Messrs. Osborn, most of the files now made are cut on the firm's own machines, the "Weed" [4]. They have about sixty of these machines in use, and they turn out from four to five times the number which can be produced by hand cutting.

The machines used produce the usual diagonal cuts and spiral teeth. The object of the latter is to avoid the numerous resettings which are required for producing the series of separate cuts that are made on the convex surfaces of round files. The file is rotated during the cutting, so forming a continuous, spiral-shaped tooth. In each machine the file is carried on a bed which fits in a half-round slide to provide for twisting when necessary. The bed is traversed longitudinally with a screw. The chisel is carried in a head above, and receives its strokes from a cam shaft. Suitable means of regulation for the relative movements of chisel and file are provided. Each machine has its own electric lamp. Eight sizes are built, which deliver from 720 to 1280 cuts per minute. Rasps are cut on different machines by means of a tool which digs out the metal.

As the files are softened by the annealing they have to be hardened after the cutting. This is a delicate operation, requiring a careful regulation of temperature, and the avoidance of curving or cracking in cooling. The files are covered first with a carbon composition to protect the teeth from becoming clogged with the lead in which they are heated. Half-round files have to be curved in the longitudinal direction before they are hardened, in order to counteract a curving which they take in hardening. This initial curving or "camber" is done in the opposite direction—that is, it is made concave on the half-round side. In a large file this may amount to ¼ in. Fine files [5] are smoothed by hand to get an absolutely level surface.

Hardening Files. The files are heated in a coke fire or in a bath of lead [6], the first being a phase of practice now disappearing. The teeth were protected by drawing the files through beer grounds or yeast, followed by drawing them through a mixture of common salt with roasted and powdered cow's hoof. The fusion of the salt indicates the proper heat for hardening, which corresponds with a cherry-red. Previous to this, at a dull red, correction is made, if necessary, by straightening a bent file across two blocks of lead, using a lead hammer in order not to damage the teeth. The files are hardened by quenching in brine.

When the files are heated in a lead bath, they float, and the workman puts them in and removes them in rotation, leaving them in long enough for the heat to penetrate. They are quenched in brine. Thence they are taken to be cleansed, which is done by a jet of steam directing a fine stream of sand on the teeth. The tangs are tempered or softened by grasping the files with heated tongs, or dipping them into a bath of lead, and the files are finished by oiling them. Inspection and packing follow.

JOSEPH G. HORNER

Algebraic Definition. Reduction to Lowest Terms. Reduction to a Common Denominator. Addition, Subtraction, and Multiplication of Fractions.

ALGEBRAIC FRACTIONS

FRACTIONS

79. In Article **70** of Arithmetic we saw that to obtain the fraction $\frac{3}{7}$ we must divide a unit into 7 equal parts and take 3 of them. Similarly, *when a and b are positive whole numbers*, we obtain the fraction $\frac{a}{b}$ by dividing a unit into b equal parts and taking a of them.

It is clear that, with this definition, the values of a and b must be restricted to positive whole numbers; for there would be no meaning in the definition if a had such a value as -4, and b the value $\frac{2}{3}$. We cannot "divide a unit into $\frac{2}{3}$ equal parts and take -4 of them."

We must, therefore, find a definition for the fraction $\frac{a}{b}$ which will apply to cases in which a and b are not positive whole numbers.

Using the definition given, let us multiply $\frac{a}{b}$ by b. To do this we must take each of the a parts b times. This gives ab parts altogether; and, since each b parts make a unit, ab parts will make a units. Therefore

$$\frac{a}{b} \times b = a. \qquad (1)$$

Hence we may take for our definition, *the fraction $\frac{a}{b}$ is the quantity which must be multiplied by b to obtain a.*

Divide both sides of the equation (1) by b, and we obtain

$$\frac{a}{b} = a \div b.$$

Thus, we may also define the fraction $\frac{a}{b}$ as *the quotient obtained by dividing a by b.*

80. As in Arithmetic, the whole theory of fractions depends on the following proposition.

The value of a fraction is unaltered when its numerator and denominator are multiplied by the same quantity.

We have already proved, in the last Article, that

$$\frac{a}{b} \times b = a.$$

Hence, multiplying both sides of the equation by m, we see that

$$\frac{a}{b} \times bm = am.$$

Thus, $\frac{a}{b}$ is the quantity which, when multiplied by bm, gives am.

But, by the definition of a fraction, the quantity which, multiplied by bm, gives am, is $\frac{am}{bm}$. Hence

$$\frac{a}{b} = \frac{am}{bm}$$

so that, for all values of a, b, and m, the value of the fraction $\frac{a}{b}$ is unaltered when we multiply both numerator and denominator by m.

81. We have proved that $\frac{a}{b} = \frac{am}{bm}$. But, if we divide both numerator and denominator of $\frac{am}{bm}$ by m we obtain $\frac{a}{b}$.

Thus, the value of a fraction is unaltered if we *divide* both numerator and denominator by the same quantity.

82. Reduction to Lowest Terms. A fraction is said to be in its lowest terms when the numerator and denominator contain no common factors. Hence, to reduce a fraction to its lowest terms, we must divide numerator and denominator by their H.C.F.

If the factors of the numerator and denominator can be easily found, the *common* factors are obvious, and can then be rejected. If the factors cannot be found by inspection, we find the H.C.F. by the rule of Art. **69**, and then divide numerator and denominator by the H.C.F.

Example **1**. Reduce

$$\frac{14x^2y^2z}{21xyz^3}$$

to its lowest terms.

The H.C.F. of the numerator and denominator is $7xyz$. Dividing the numerator by $7xyz$ we obtain $2xy$; and by dividing the denominator by $7xyz$ we obtain $3z^2$. Hence the given fraction is equal to $\frac{2xy}{3z^2}$.

Example **2**. Reduce

$$\frac{x^2 + 6xy - 7y^2}{x^2 + 9xy + 14y^2}$$

to its lowest terms.

Resolve the numerator and denominator into their simplest factors, and then reject those which are common. Thus

$$\frac{x^2 + 6xy - 7y^2}{x^2 + 9xy + 14y^2} = \frac{(x + 7y)(x - y)}{(x + 7y)(x + 2y)}$$
$$= \frac{x - y}{x + 2y} \quad \underline{Ans.}$$

Example 3. Reduce

$$\frac{x^3-5x^2-8x+12}{x^4-7x^3+7x^2-7x+6}$$

to its lowest terms.

In cases of this sort, before resorting to the H.C.F. rule, always try whether any factors can be found by the Remainder Theorem [Art. 65].

In this example, the numerator vanishes when we put $x=1$. Hence $x-1$ is a factor, and we have

$$\begin{aligned} x^3-5x^2-8x+12 &= x^2\ (x-1)-4x\ (x-1) \\ &\quad -12\ (x-1) \\ &= (x-1)\ (x^2-4x-12)\ \text{[Art. 65, Ex. 1]} \\ &= (x-1)\ (x+2)\ (x-6). \end{aligned}$$

We have now simply to try which of these factors divides the denominator. We find, by substituting $x=1$ and $x=6$ that the denominator vanishes, but that it does not vanish for the value $x=-2$. Thus $(x-1)\ (x-6)$ is a factor of the denominator.

By actual division, $(x-1)\ (x-6)$, or x^2-7x+6 divided into the denominator, gives x^2+1 for quotient.

Or, the same result may be arrived at in a manner similar to that of Art. 65, Ex. 1. Thus

$$\begin{aligned} x^4-7x^3+7x^2-7x+6 &= x^2\ (x^2-7x+6)+(x^2 \\ &\quad -7x+6) \\ &= (x^2-7x+6)\ (x^2+1). \end{aligned}$$

Hence, the given fraction

$$=\frac{(x-1)\ (x+2)\ (x-6)}{(x-1)\ (x-6)\ (x^2+1)}=\frac{x+2}{x^2+1}\ \underline{Ans.}$$

EXAMPLES 23

Reduce to their lowest terms

1. $\dfrac{28a^2bc^2}{63a^4b^2c}$.
2. $\dfrac{12a^6b^2x^3y}{30ab^4x^2y^2}$.
3. $\dfrac{a^2-ab}{ab-b^2}$.
4. $\dfrac{x^4-x^2}{x^4+x^3}$.
5. $\dfrac{x^2-5x+6}{x^2+3x-10}$
6. $\dfrac{x^2-4x-21}{x^2-3x-18}$.
7. $\dfrac{1-2a+a^2-2a^3}{2-4a+a^2-2a^3}$.
8. $\dfrac{15a^3b+39a^2b-18ab}{10a^2b^2+6ab^2-4b^2}$.
9. $\dfrac{x^4-13x^2+36}{x^4-x^3-7x^2+x+6}$.
10. $\dfrac{8x^3-10x^2-16x-3}{6x^4-22x^3+31x^2-23x-7}$.

83. Reduction to a Common Denominator. We have seen [Art. 80] that the value of a fraction is unaltered when we multiply both numerator and denominator by the same quantity. Hence a fraction can always be expressed with a denominator which is some multiple of its original denominator. It follows, therefore, that any number of fractions can be expressed with a denominator which is some *common* multiple of the original denominators. There is generally a saving of labour if we use the *least* common multiple. The process is like that explained for Arithmetic [page 935].

Example. Reduce

$$\frac{1}{x-y},\ \frac{1}{x+y},\ \text{and}\ \frac{2y}{x^2+y^2}$$

to a common denominator.

The L.C.M. of $x-y$, $x+y$, and x^2+y^2 is $(x-y)\ (x+y)\ (x^2+y^2)$. Dividing the first denominator, $x-y$, into this common denominator, we obtain $(x+y)\ (x^2+y^2)$ for quotient. We must, therefore, multiply both numerator and denominator of the first fraction by $(x+y)\ (x^2+y^2)$. Similarly, we must multiply numerator and denominator of the second fraction by $(x-y)\ (x^2+y^2)$, and of the third fraction by $(x-y)\ (x+y)$. Thus, we obtain

$$\frac{1}{x-y}=\frac{(x+y)\ (x^2+y^2)}{(x-y)\ (x+y)\ (x^2+y^2)}=\frac{x^3+x^2y+xy^2+y^3}{x^4-y^4}$$

$$\frac{1}{x+y}=\frac{(x-y)\ (x^2+y^2)}{(x+y)\ (x-y)\ (x^2+y^2)}=\frac{x^3-x^2y+xy^2-y^3}{x^4-y^4}$$

$$\frac{2y}{x^2+y^2}=\frac{2y\ (x-y)\ (x+y)}{(x^2+y^2)\ (x-y)\ (x+y)}=\frac{2x^2y-2y^3}{x^4-y^4}.$$

84. Addition and Subtraction of Fractions. If two fractions have the same denominator, their sum or their difference will have that denominator. The numerator is formed by taking the sum, or the difference, of the numerators. The result must be reduced to lower terms, if necessary. Thus, the sum of the fractions $\dfrac{a}{a+b}$ and $\dfrac{b}{a+b}$ is $\dfrac{a+b}{a+b}$, which reduces to 1. The difference of the same two fractions is $\dfrac{a-b}{a+b}$.

If the fractions have not the same denominators, we first reduce them to a common denominator [Art. 83] and then proceed as above.

Example 1. Find the value of

$$\frac{1}{a-2}+\frac{1}{a+2}.$$

The L.C.M. of the denominators is $(a-2)\ (a+2)$. Hence,

$$\begin{aligned} \frac{1}{a-2}+\frac{1}{a+2} &= \frac{a+2}{(a-2)\ (a+2)}+\frac{a-2}{(a-2)\ (a+2)} \\ &= \frac{a+2+a-2}{(a-2)\ (a+2)} \\ &= \frac{2a}{a^2-4}\ \underline{Ans.} \end{aligned}$$

When there are several fractions, some of which are to be added, and some subtracted, the method is the same.

Example 2. Find the value of

$$\frac{2}{x^2-1}+\frac{3}{x^2-4x+3}-\frac{4}{x^2-2x-3}.$$

The given expression

$$\begin{aligned} &=\frac{2}{(x-1)\ (x+1)}+\frac{3}{(x-1)\ (x-3)}-\frac{4}{(x+1)\ (x-3)} \\ &=\frac{2\ (x-3)+3\ (x+1)-4\ (x-1)}{(x-1)\ (x+1)\ (x-3)} \\ &=\frac{2x-6+3x+3-4x+4}{(x-1)\ (x+1)\ (x-3)} \\ &\frac{x+1}{(x-1)(x+1)(x-3)}=\frac{1}{(x-1)(x-3)}=\frac{1}{x^2-4x+3} \\ &\underline{Ans.} \end{aligned}$$

Sometimes it is better not to reduce all the fractions to a common denominator at once, as in the following example:

Example 3. Find the value of

$$\frac{1}{a-x}-\frac{1}{a+x}-\frac{2x}{a^2+x^2}-\frac{4x^3}{a^4+x^4}.$$

Taking the first two fractions we have

$$\frac{1}{a-x}-\frac{1}{a+x}=\frac{(a+x)-(a-x)}{a^2-x^2}=\frac{2x}{a^2-x^2}.$$

Next, take this result and the third of the given fractions, thus

$$\frac{2x}{a^2-x^2}-\frac{2x}{a^2+x^2}=\frac{2x(a^2+x^2)-2x(a^2-x^2)}{a^4-x^4}=\frac{4x^3}{a^4-x^4}.$$

Finally, the result just obtained, and the last fraction, give

$$\frac{4x^3}{a^4-x^4}-\frac{4x^3}{a^4+x^4}=\frac{4x^3(a^4+x^4)-4x^3(a^4-x^4)}{a^8-x^8}$$

$$=\frac{8x^7}{a^8-x^8}\ \textit{Ans.}$$

85. We have defined the fraction $\frac{a}{b}$ as the quotient obtained by dividing a by b. But, by the rule of signs, the same result is obtained when we divide $-a$ by $-b$. That is,

$$\frac{a}{b}=\frac{-a}{-b}.$$

Hence, *if the signs of both numerator and denominator be changed, the sign of the whole fraction is unaltered.*

Again, the fraction $\frac{-a}{b}$ is the quotient obtained by dividing $-a$ by b. This quotient, by the rule of signs, is of opposite sign to that obtained by dividing a by b. That is

$$\frac{-a}{b}=-\frac{a}{b}.$$

In a similar way we see that

$$\frac{a}{-b}=-\frac{a}{b}.$$

Hence, *if the sign of either the numerator or the denominator be changed, the sign of the whole fraction will be changed.*

Example: Simplify

$$\frac{a}{(a-b)(a-c)}+\frac{b}{(b-c)(b-a)}+\frac{c}{(c-a)(c-b)}.$$

Here, although there are apparently six different factors in the denominators, we notice that three of them are obtained from the other three by changing the signs. Thus $b-a$ is simply $a-b$ with the signs changed.

We therefore write the six factors in *Cyclic Order*, *i.e.*, we write them so that c always follows b, a always follows c, and b always follows a, thus $b-c$, $c-a$, $a-b$.

In the present example we must change the sign of one factor of the denominator, writing $(c-a)$ instead of $(a-c)$, and so on. This, of course, changes the sign of the whole fraction. Thus the given expression

$$=-\frac{a}{(a-b)(c-a)}-\frac{b}{(b-c)(a-b)}-\frac{c}{(c-a)(b-c)}$$

$$=\frac{-a(b-c)-b(c-a)-c(a-b)}{(b-c)(c-a)(a-b)}$$

$$=\frac{-ab+ca-bc+ab-ca+bc}{(b-c)(c-a)(a-b)}$$

$$=\frac{0}{(b-c)(c-a)(a-b)}=0\ \textit{Ans.}$$

EXAMPLES 24

Reduce to their simplest form

1. $\frac{x-y}{x+y}-\frac{x+y}{x-y}$.
2. $\frac{x-2}{3x+1}-\frac{x+2}{3x-1}$.
3. $\frac{1}{x+1}+\frac{2x}{(x+1)^2}-\frac{3x^2}{(x+1)^3}$.
4. $\frac{2x}{x+y}+\frac{2y}{x-y}-\frac{x^2+y^2}{x^2-y^2}$.
5. $\frac{x-a}{x+a}+\frac{x+a}{x-a}+\frac{x^2-5a^2}{x^2-a^2}$.
6. $\frac{2}{a^2+a}+\frac{2a-1}{a^2-a+1}-\frac{2a^3-1}{a^4+a}$.
7. $\frac{1}{1-x}+\frac{1}{1+x}+\frac{2}{1+x^2}+\frac{2}{1+x^4}$.
8. $\frac{1}{x-y}+\frac{2}{x-2y}+\frac{2}{x+2y}+\frac{1}{x+y}$.
9. $\frac{a-4}{a^2-5a+6}-\frac{a-10}{2a^2-5a-3}+\frac{a-7}{2a^2-3a-2}$.
10. $\frac{b+c}{(a-b)(a-c)}+\frac{c+a}{(b-c)(b-a)}+\frac{a+b}{(c-a)(c-b)}$
11. $\frac{2+3a}{3-a}-\frac{2-3a}{3+a}+\frac{22a-3}{a^2-9}$.
12. $\frac{x(y+z-x)}{(y+z)^2-x^2}+\frac{y(z+x-y)}{(z+x)^2-y^2}+\frac{z(x+y-z)}{(x+y)^2-z^2}$

86. **Multiplication of Fractions.** Let $\frac{a}{b}$ and $\frac{c}{d}$ be two fractions, and let x denote their product $\frac{a}{b}\times\frac{c}{d}$. Then

$$x\times b\times d=\frac{a}{b}\times\frac{c}{d}\times b\times d.$$

$$=\left(\frac{a}{b}\times b\right)\times\left(\frac{c}{d}\times d\right)$$

since the factors of a product may be taken in any order [Art. 22].

But $\frac{a}{b}\times b=a$, and $\frac{c}{d}\times d=c$ [Art. 79].

Therefore

$$xbd=ac;$$

or, x is the quantity which gives ac when multiplied by bd. But from the definition of fraction $\frac{ac}{bd}$ is that quantity. Hence,

$$x=\frac{ac}{bd};$$

or

$$\frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd}.$$

Therefore, *the product of two fractions is a fraction whose numerator is the product of the numerators of the fractions and whose denominator is the product of their denominators.*

The product of any number of fractions is formed in the same way. Thus

$$\frac{a}{b}\times\frac{c}{d}\times\frac{e}{f}=\frac{ace}{bdf}.$$

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